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QUESTIONS ON CHEMISTRY.

QUESTIONS

ON

CHEMISTRY.

A SERIES OF PROBLEMS AND EXERCISES IN INORGANIC AND ORGANIC CHEMISTRY.

BY

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SECTION I.

NON-METALS.

QUESTIONS ON CHEMISTRY.

SECTION I.—NON-METALS.

INTRODUCTORY SUBJECTS.

1. WHAT is meant (*a*) by chemical action, (*b*) by physical change?

2. Give some familiar examples of chemical action and physical change.

3. Explain the terms chemical combination and chemical decomposition. Give examples.

4. Matter is said to be indestructible. Explain this statement, and describe an experiment in support of it.

5. The following substances are heated to redness in air—(*a*) platinum, (*b*) magnesium, (*c*) mercuric oxide. What occurs in each case?

6. Some finely divided copper is placed in an open crucible and its weight ascertained. It is then heated to redness, allowed to cool, and when re-weighed is found to have gained in weight. How is this accounted for?

7. Name the elements contained in an ordinary candle, and explain fully the chemical changes which occur when it burns in air.

8. When the products from the burning of a candle are collected and weighed, do they weigh more or less than the original candle? What is the cause of the difference in weight?

9. What is the difference between elements and compounds? Give six examples of each.

10. Into what two classes are elements divided, and how many are in each class?.

11. Make a sketch of a chemical balance and explain its construction. Who first introduced the use of the balance in chemical investigations?

12. How would you endeavour to ascertain whether a certain substance was an element or a compound?

13. Name the most abundant elements (*a*) in the earth, (*b*) in the air.

14. What is meant by each of the following terms—

(*a*) chemical test, (*b*) analysis, (*c*) synthesis? Give examples of each.

15. Distinguish the elements from the compounds in the following list of substances:—sand, sugar, ozone, phosphorus, glass, water, lime, chlorine, chalk, nitre, diamond, mercury, common salt, silver and potassium chlorate.

16. Name the non-metallic elements, and state which are most abundant in nature.

17. Each element has a certain symbol, combining weight, and density. Explain these terms.

18. What is the weight in grammes of a litre of hydrogen at the normal temperature and pressure? (*i.e.* at a temperature of 0° C. and under a pressure of 760 millimetres of mercury = N.T.P.).[1] Why is it important to remember this weight and what name has been given to it?

19. Give the weight in grammes at N.T.P. of a litre of each of the following gases—oxygen, chlorine, nitrogen, carbon dioxide and hydrochloric acid.

---

[1] It is convenient to indicate these conditions by a shorter expression. Here and elsewhere in the book "normal temperature and pressure" is contracted thus, N.T.P.

20. A certain volume of oxygen weighs 1 gramme. Find the weights at the same temperature and pressure of the same volume of carbon dioxide, nitrogen, chlorine, ammonia, and hydrochloric acid.

21. How are the French measures of weight and capacity derived from the measures of length?

22. How many grains are in a gramme, how many inches in a metre, and how many cubic centimetres in a litre?

23. Find the dimensions of a room in metres which is 24 feet long by 15 broad and 13 high.

24. A sample of water contains 2·23 grammes of solid matter in a litre. How many grains per gallon does this correspond to?

25. State shortly the laws enunciated by Dalton and by Gay Lussac on the subject of chemical combination.

26. Chemical combination is said to take place in certain definite proportions. Explain this and give an example.

27. One hundred pounds of copper are heated with the same weight of sulphur till combination takes place. Which element would be found in excess after the reaction, and how much of it?

28. 63·5 grammes of copper, 207 grammes of lead, and 24 grammes of magnesium are separately heated in air till they cease to gain in weight. How many grammes will each gain?

29. A solution contains 159·5 grammes copper sulphate. How much iron is required to precipitate all the copper, and what weight of ferrous sulphate is formed?

30. In what proportions (*a*) by weight, (*b*) by volume, do oxygen and hydrogen unite together? Answer the question also for hydrogen and chlorine.

31. Find the volumes at N.T.P. of 1 gramme hydrogen, 16 grammes oxygen, 14 grammes nitrogen, 35·5 grammes chlorine, 80 grammes bromine vapour, 9 grammes water vapour, 18·25 grammes hydrochloric acid, and 22 grammes carbon dioxide.

32. Name the elements represented by the following symbols:—C, Cl, Cu, Ca, Cd, Co, S, Si, Sr, Mg, Mn, K, Ag, Hg, Sb, Pb, and Na.

33. Express the following equations in words:—

$$\begin{aligned} H + Cl &= HCl. \\ H_2 + O &= H_2O. \\ Cu + S &= CuS. \\ P_2 + O_5 &= P_2O_5. \end{aligned}$$

34. Give the combining weight of each element, and the molecular weight of each compound mentioned in the previous question.

35. Find the molecular weights of the compounds represented by the following formulæ :—$CuSO_4$, HNO_3, H_2SO_4, $AgNO_3$, NH_4Cl, $Pb(NO_3)_2$, Na_2HPO_4, $CaCO_3$, $(NH_4)_2SO_4$ and $Cr_2K_2(SO_4)_4 + 24H_2O$.

36. Give the formulæ for hydrochloric acid and for the chlorides of,

Sodium, potassium, and silver (monads) ;
Calcium, zinc, lead, and barium (dyads) ; and for
Gold and boron (triads).

37. Give the formulæ for nitric and sulphuric acids, and for the nitrates and sulphates of potassium, silver, calcium, and lead.

MONADS.

HYDROGEN.

38. How is hydrogen found in the free state in nature? How does it occur in combination?

39. How long has hydrogen been known? Who first obtained it pure and described its properties?

40. Give three distinct reactions by means of which hydrogen may be obtained from water. Give equations for each reaction.

41. How is hydrogen usually prepared, and what impurities may it contain when prepared by this method?

42. What occurs when zinc is heated with a strong solution of caustic potash or soda? Give an equation.

43. How could you obtain hydrogen from (*a*) hydrochloric acid gas, (*b*) ammonia gas, (*c*) marsh gas?

44. Name any four metals which if dropped into hydrochloric or sulphuric acids decompose these acids with evolution of hydrogen. Give equations.

45. Equal weights of potassium, lithium, and sodium, are placed in contact with water, and the hydrogen produced by each reaction is collected separately. Which metal will yield the greatest volume, and why?

46. What weight of hydrogen should be evolved by throwing 11·5 grammes of sodium on water, and what volume should it occupy at N.T.P.?

47. How much zinc must be dissolved in acid so as to yield exactly one litre of hydrogen at N.T.P.?

48. Two hundred and fifty c.c. of hydrogen were obtained by dissolving iron in hydrochloric acid. How much of the metal was used?

49. A gas-holder has the capacity of 1 cubic metre. Find the weight of zinc and sulphuric acid which must be used to fill it with hydrogen measured at N.T.P.?

50. One hundred and twentry-three grammes of magnetic iron oxide remained in a tube in which iron had been heated in a current of steam. How much hydrogen was obtained, and what weight of iron oxidized?

51. Two hundred and seventy-six grammes of potassium are thrown on water. Give the volume of gas liberated and the weight of potash formed.

52. What are the chief properties of hydrogen?

Describe experiments which show its lightness and rapid diffusion.

53. Sketch the apparatus you would use to demonstrate that hydrogen may be syphoned.

54. A burning jet of hydrogen is placed successively in air, in oxygen, in hydrogen, and in chlorine. State exactly what occurs in each case.

55. By what methods have Pictet and Cailletet liquefied hydrogen? Give a short account of previous unsuccessful attempts to effect this result.

56. The captive balloon at Paris in 1878 was 36 metres in diameter and spherical. What volume of gas at N.T.P. is required to fill it? What weight of hydrogen would be required?

57. What impurities are generally found in hydrogen prepared by the action of acids on zinc, and how may they be completely removed?

58. What impurity is always present in hydrogen which has been dried by passing the gas over strong sulphuric acid? Explain its presence.

59. If you were provided with magnesium, sulphuric acid, water, and a graduated cylinder, how could you ascertain the combining weight of hydrogen?

HYDROGENIUM (ALLOTROPIC HYDROGEN).

60. Give a short account of the substance called by Graham "hydrogenium," and state how it is prepared.

61. Explain the terms "occlusion," "diffusion," "effusion," and "transpiration" of gases. Give examples of each.

62. How has the density of hydrogenium been ascertained? In what respects does hydrogenium resemble a metal?

63. Contrast the chemical properties of hydrogen with those of hydrogenium.

64. Give an example of a reaction in which hydrogen acts like a metal. What property, characteristic of metals and their compounds, is possessed by hydrogenium?

CHLORINE.

65. By whom and in what year was chlorine gas discovered? By whom and when was it shown to be an element?

66. Name several commonly-occurring compounds which contain chlorine.

67. Give three distinct methods for obtaining chlorine from hydrochloric acid.

68. What is the action of hydrochloric acid on sodium hypochlorite, on potassium chlorate, and on nitric acid?

69. One hundred grammes of manganese dioxide are treated with excess of hydrochloric acid. How much chlorine is evolved? If treated with the proper quantities of sodium chloride and sulphuric acid how much more would be obtained?

70. Seven litres of hydrochloric acid gas at N.T.P. are passed over heated manganese dioxide. Give the weight and volume of chlorine produced.

71. How much chlorine gas should be obtained by heating with excess of hydrochloric acid, 129 grammes of pyrolusite containing 4·7 per cent. of impurities?

72. What occurs when an electric current is passed through a strong solution of hydrochloric acid? Describe exactly how the experiment should be made.

73. By the electrolysis of a certain quantity of hydrochloric acid, 224 c.c. of chlorine at N.T.P. were obtained. Find the weight and volume of hydrogen obtained at the same time and the weight of acid decomposed.

74. How is chlorine prepared (*a*) by Deacon's process,

(*b*) by Weldon's process? Discuss the advantages of each method.

75. One hundred c.c. of manganese liquor contain 27·3 grammes manganese chloride. How much chlorine should be obtained from 1,000,000 gallons of such liquor, treated by Weldon's process?

76. Thirteen cwts. of common salt containing 2·7 per cent. impurity are decomposed by sulphuric acid, and the evolved gas is treated by Deacon's process. How much chlorine should be obtained?

77. What impurities are likely to be contained in chlorine gas as ordinarily prepared, and how may they be removed?

78. At what temperature would a litre of chlorine weigh the same as a litre of hydrogen?

79. Name any chlorides which evolve chlorine on heating. Give equations.

80. If chlorine be passed into ice-cold water, what occurs? What happens when the dried product is gently heated in a sealed tube?

81. Describe some experiments to show the tendency of chlorine to unite with other elements. Name the metalloids with which it does not directly combine.

82. Chlorine unites readily with free hydrogen. How may this be shown experimentally?

83. Describe several experiments which show the union of chlorine with combined hydrogen.

84. State fully what occurs when a lighted taper is placed in chlorine gas.

85. What occurs when the following bodies are separately brought in contact with chlorine gas? (*a*) phosphorus, (*b*) turpentine, (*c*) indigo, (*d*) antimony, (*e*) olefiant gas, (*f*) mercury.

86. How does chlorine act as a bleaching agent? Explain why the presence of water is necessary.

87. How does freshly prepared chlorine water differ from the same substance after exposure to light?

88. What occurs when a mixture of chlorine and steam is passed through a red-hot porcelain tube?

89. Fourteen grammes of iron are dissolved in hydrochloric acid. How much hydrogen (at N.T.P.) is evolved, and what volume of chlorine is needed to convert the ferrous into ferric chloride?

90. Give several examples of chlorine acting as an oxidizing agent.

91. What occurs when perfectly dry chlorine is passed

over (*a*) fused sodium, (*b*) heated quicklime, (*c*) slaked lime, (*d*) heated diamond?

92. How could you obtain chlorine from common salt without using manganese dioxide?

BROMINE.

93. By whom and when was bromine discovered? Name the naturally occurring compounds which contain it.

94. What is kelp, and how is bromine obtained from it?

95. How may the presence of bromine in a mineral water be detected?

96. What occurs when bromine is added to (*a*) ether, (*b*) potash, (*c*) antimony?

97. Chlorine water is dropped into solution of potassium bromide, and bromine water is dropped into solution of potassium iodide. What occurs in each case?

98. Give two distinct methods for the preparation of bromine from potassium bromide.

99. A sample of sea-water contained 0·36 parts magnesium bromide in 1,000. How much of it would be required to yield one litre of bromine? S. G. = 3·187.

100. Contrast the properties of chlorine with those of bromine and point out the differences between them.

101. How may bromine be made to combine with (*a*) free hydrogen, (*b*) hydrogen in compounds?

102. What occurs when bromine water is treated (*a*) with sulphuretted hydrogen, (*b*) with sulphurous acid?

103. A piece of antimony was completely converted into tribromide by the absorption of 187 c.c. bromine vapour at N.T.P. Find the weight of the antimony.

IODINE.

104. Give a short account of the history and occurrence of iodine.

105. How is kelp prepared, and by what other names is it known? Name all the products which are practically obtained from it.

106. A sample of water contains four parts calcium iodide in 1,000,000. What volume of chlorine at N.T.P. would exactly liberate the iodine from a kilogramme of the water?

107. Describe fully the preparation of iodine from kelp and state how the crude product is purified.

108. What is the weight of one litre of iodine vapour at N.T.P.? Give the volume of hydrogen and of air which would weigh the same as the iodine.

109. How much sulphuric acid and manganese dioxide would be needed to liberate all the iodine from 379 grammes of potassium iodide?

110. Four thousand three hundred and twenty-one c.c. of chlorine at N.T.P. were required to liberate all the iodine from a solution of potassium iodide. How much of this salt was present?

111. How is iodine tested for when in the free state? How is it detected when in combination?

112. Name the impurities usually present in commercial iodine and state how it may be obtained chemically pure.

113. To an aqueous solution of potassium iodide and starch, chlorine water is added drop by drop. What occurs? On adding excess of chlorine water what takes place? Explain both reactions.

114. Chlorine, bromine, and iodine are separately added to solutions of (*a*) potassium iodide, (*b*) potassium bromide (*c*) potassium chloride. What occurs in each case?

115. 0·5205 gramme of an oxide of manganese was treated with hydrochloric acid and the evolved chlorine

was led into solution of potassium iodide. The liberated iodine required 165·4 c.c. of a standard solution of sodium thiosulphate, of which 1 c.c. was equal to 0·005 gramme iodine. Find percentage of manganese dioxide in the oxide.

116. One hundred and nineteen grammes of iodine are suspended in water. What volume of chlorine at N.T.P. will be required to convert all the iodine into iodic acid?

117. Seventy-three c.c. of a solution of iodine (containing 12·7 grammes per litre) were added to a mixture of sulphuretted hydrogen and starch before a permanent blue coloration was obtained. Find the amount of sulphuretted hydrogen present.

FLUORINE.

118. Give the names and formulæ of the chief minerals containing fluorine, and name substances in which it is always found in minute quantity.

119. Describe the various attempts which have been made to isolate fluorine.

120. What is the action of fluorine on (*a*) hydrogen, (*b*) water, (*c*) platinum, (*d*) silica?

121. Find the percentage of fluorine in fluor spar and cryolite.

122. How may the presence of fluorine in a compound be ascertained?

123. Give the formulæ of the fluorides of (*a*) hydrogen, (*b*) silver, (*c*) silicon, (*d*) boron, (*e*) calcium, (*f*) potassium.

124. Berzelius found that when 100 parts of calcium fluoride were heated with sulphuric acid till completely decomposed, 175 parts calcium sulphate were obtained. Calculate the atomic weight of fluorine from these data. Later experiments gave 174·5 parts calcium sulphate. Calculate the atomic weight from this result.

125. 3·2617 grammes of calcium fluoride when treated with strong sulphuric acid, yielded 5·6867 grammes of calcium sulphate. From these data calculate the atomic weight of fluorine.

DYADS.

OXYGEN.

126. How does oxygen occur in the free state and in the combined state in nature?

127. What proportion of (*a*) air, (*b*) water, (*c*) the earth's crust, consists of oxygen?

128. By whom was oxygen discovered, and in what year? Who discovered it independently, and when?

129. What name was given to oxygen by its discoverer? Who proposed the name oxygen, and for what reasons?

130. From what substance was oxygen first prepared? Describe the form of apparatus originally used, and state how the experiment would be made now.

131. Express by equations the reactions which occur when (*a*) potassium chlorate, (*b*) mercuric oxide, (*c*) manganese dioxide, are strongly heated.

132. Why is manganese dioxide generally mixed with potassium chlorate for the preparation of oxygen?

133. What impurity is always present in oxygen prepared by heating a mixture of potassium chlorate and manganese dioxide? How may this impurity be removed?

134. Name six oxides which when simply heated lose oxygen. Express each reaction by an equation.

135. How may oxygen be obtained from each of the following bodies?—(*a*) water, (*b*) sulphuric acid, (*c*) potassium bichromate, (*d*) bleaching powder.

136. How may oxygen be obtained from potassium manganate and from potassium permanganate?

137. Describe fully any process for obtaining oxygen from the air,

138. What processes have been proposed for obtaining continuous supplies of oxygen from the air?

139. How may oxygen be obtained from (*a*) lime, (*b*) ferric oxide, (*c*) silica, (*d*) nitric acid?

140. Give two distinct methods for the preparation of oxygen from water, and sketch the apparatus necessary for each.

141. Find the percentage of oxygen contained in each of the following substances:—(*a*) water, (*b*) potassium

chlorate, (*c*) manganese dioxide, (*d*) sulphuric acid, (*e*) mercuric oxide, (*f*) barium dioxide.

142. How much oxygen should be obtained from 100 lbs. of each of the above substances when used as sources of oxygen?

143. How much mercuric oxide must be heated to yield one litre of oxygen at N.T.P.?

144. Equal weights of manganese dioxide are heated (*a*) alone, (*b*) with sulphuric acid. Which process yields the greater amount of oxygen?

145. Exactly 100 litres of oxygen at N.T.P. were obtained by heating potassium chlorate. How much of this salt was used?

146. Some pure manganese dioxide lost when strongly heated 137 grammes. Find the weight of the residue and the volume (at N.T.P.) of oxygen evolved.

147. A quantity of mercury was heated in air for several days, and gained in weight 13·4 grammes. Find the volume of oxygen at N.T.P. removed from the air.

148. Four hundred and seventy-nine grammes of potassium chloride remained after heating some potassium chlorate. Find the weight of the latter salt used.

149. A glass flask filled with air at N.T.P. weighs 52

grammes. What capacity must it have so that when filled with oxygen at 14° C. and 753 m.m. pressure, it shall weigh 53·47 grammes?

150. What are the most important properties of oxygen? How is it distinguished from other gases?

151. How did Pictet obtain the gas in the liquid state and ascertain its density?

152. The following bodies are separately burned in oxygen, (*a*) hydrogen, (*b*) sulphur, (*c*) charcoal, (*d*) iron, (*e*) phosphorus, (*f*) magnesium. Give the name of the oxide formed in each case, and express all the reactions by equations.

153. Explain the terms "combustion," "oxidation," "reduction," and "deoxidation."

154. Sulphur is burnt in a jar of air, and also in a jar of oxygen. Name the gases present in each jar after the combustion, and state the action of water on each.

155. Why was the name oxygen given to the gas, and why is it inappropriate? To what element would the name more suitably apply?

156. What chemical changes occur when a candle burns in oxygen? How may each of the products be recognised?

157. At the bottom of a glass flask some sand is placed and on the top of it a fragment of phosphorus. The flask is then filled with dry oxygen, closed air-tight, and the whole weighed. The flask is then warmed until the phosphorus kindles, and when quite cold re-weighed. The stopper is removed for an instant and a third weighing made. How will the three weighings differ?

158. If air were used instead of oxygen in the previous question, what difference would be noticed in the weighings?

159. By burning a candle in oxygen 13·21 grammes carbon dioxide and 5·58 grammes water were produced. What loss in weight did the candle suffer, and what volume of oxygen at N.T.P. was required for the combustion?

160. What weight of oxygen is contained in a room measuring 23 feet long, 17 broad, and 13 high? With how much phosphorus would this quantity of oxygen combine?

OZONE (ALLOTROPIC OXYGEN).

161. What is meant by the term allotropism? Give examples of elements which occur in allotropic forms.

162. Give a short account of the history of ozone, and state how it was first prepared.

163. How does ozone occur in nature? How is its presence usually detected?

164. Describe six distinct methods by which ozone may be prepared.

165. Name all the gases which liberate iodine from potassium iodide.

166. How may oxygen be converted into ozone, and *vice versâ*?

167. Can a given volume of oxygen be entirely converted into ozone, and if so, by what method?

168. What change in bulk occurs when oxygen is converted into ozone? Describe the apparatus of Andrews and Tait for showing this.

169. The formula of ozone is O_3. Describe fully the experiments of Andrews and of Soret in support of this formula.

170. What occurs when ozone is heated to 300° C. and when sand is shaken up in contact with the gas?

171. Sketch the apparatus used by Andrews to demonstrate the presence of ozone in air.

172. Express by equations the action of ozone, and of chlorine, on potassium iodide.

173. What occurs when a hot glass rod is placed in a mixture of ether vapour and air, and when turpentine is shaken up with air or oxygen?

174. To what causes has the presence of ozone in air been attributed?

175. Compare the properties of ozone with those of oxygen, and show how they differ from each other?

176. A flask contains a colourless gas, which is found to liberate iodine from potassium iodide. How could you ascertain with certainty whether or not this reaction is due to the presence of ozone?

177. What is the action of ozone on each of the following bodies?—(*a*) mercury, (*b*) turpentine, (*c*) caoutchouc, (*d*) manganese dioxide, (*e*) lead sulphide, (*f*) barium dioxide, (*g*) finely-divided silver, and (*h*) silver oxide.

178. What is the density of ozone, and how has it been ascertained?

TRIAD.

BORON.

179. Name the most important compounds of boron which are found native.

180. How was boron first isolated by Gay-Lussac and Thenard, and by Davy?

181. How may crystallized boron be obtained? By whom was it first prepared?

182. Compare the properties of the allotropic modifications of boron.

183. Express by equations the reactions which occur when potassium is heated (*a*) with boron trioxide, (*b*) with potassium borofluoride.

184. Amorphous boron is heated in (*a*) air, (*b*) oxygen, (*c*) nitrogen, (*d*) chlorine. What occurs in each case? Give the names and formulæ of the products.

185. What occurs when adamantine boron is strongly heated in air or oxygen? What occurs when it is fused with soda or potash?

186. One hundred and thirty-seven grammes of boric acid are heated until all the water is expelled. What weight of trioxide remains, and with how much potassium must it be heated in order to prepare boron?

187. Under what conditions is boron soluble in water?

TETRADS.

CARBON.

188. How does carbon occur in nature, (*a*) free, (*b*) combined?

189. How are the three allotropic forms of carbon proved to consist of the same substance?

190. The Koh-i-noor diamond weighs 106 carats (1 carat = 3·17 grains). What volume of oxygen at N.T.P. would be necessary to burn it, and what volume of carbon dioxide would result?

191. Give the physical properties of the three varieties of carbon, and mention the chief uses of each.

192. How may the presence of carbon in organic matter be shown?

193. By what other names is graphite known? Give the names of the different kinds of amorphous carbon, and state how each is prepared.

194. 2·62 grammes of a sample of coke yielded when

burned in oxygen 8·77 grammes carbon dioxide. Find the percentage of carbon contained in it.

195. How may graphite be obtained artificially?

196. Give an account of the different methods employed for preparing charcoal from wood. How would you demonstrate the preparation of charcoal on the small scale?

197. Although the specific gravity of charcoal is about 1·5, yet it floats on water. How is this explained? How could a piece of charcoal be made to sink in water?

198. What happens when a piece of perfectly dry charcoal is placed in a jar of ammonia gas standing over mercury? What is the cause of the change?

199. How does charcoal act as a disinfectant?

200. What happens when charcoal is heated with solution of indigo or logwood? Which kind of charcoal acts most readily on these bodies, and to what useful purpose is it applied?

201. What is coke? Give the different ways employed for preparing it.

202. How is animal charcoal prepared, and what are its properties?

203. How is the substance called gas carbon obtained, and what is it used for? How is lamp-black obtained?

204. What weight of carbon dioxide will result from burning 112 lbs. of charcoal containing 85·73 per cent. of carbon?

205. What relation has been noticed by Angus Smith to exist with regard to the volumes and weights of gases absorbed by charcoal?

SILICON.

206. Name the most abundant minerals in which silicon occurs. Name other substances of which it is an essential constituent.

207. How are the different modifications of silicon prepared? How was it originally prepared, and by whom? Give equations for all the reactions.

208. A specimen of granite contains 61 per cent. quartz, 30 per cent. potash felspar, and 9 per cent. mica. Find the percentage of silicon in the specimen.

209. Give the chief properties of amorphous and crystalline silicon, and state the action of heat, of acids, and of alkalies on each variety.

210. How much silicon should be obtained from 119 grammes of potassium silico-fluoride, and how much potassium would be needed for the decomposition?

211. One hundred and twenty-three grammes of aluminium were heated in a current of silicon tetrachloride vapour. Give the weights of the products.

PENTADS.

NITROGEN.

212. How does nitrogen occur in nature? Mention some gaseous and solid bodies which contain it.

213. When, by whom, and how was nitrogen discovered?

214. Give a full account of any experiment which proves the existence of nitrogen in air.

215. Give two methods for the preparation of nitrogen from air.

216. Give four distinct methods for obtaining nitrogen gas from compounds of nitrogen. Give equations

217. What are the properties of nitrogen?

218. What volume of chlorine must be passed through ammonia so as to yield 10 litres of nitrogen gas at N.T.P.?

219. What volume of air contains 1 gramme of nitrogen?

220. How may nitrogen be directly combined with oxygen, tungsten, carbon, boron, and magnesium?

221. How may the nitrogen contained in potassium nitrate be obtained in the free state?

222. What is the difference in weight between 10 litres nitrogen and 10 litres air, each gas being measured at N.T.P.?

PHOSPHORUS.

223. What is the chief source of phosphorus and its compounds? What is the most abundant phosphate found in nature? Name other naturally-occurring phosphates.

224. From what source do animals derive the phosphorus which is contained in their bones and blood?

225. By whom and when was each modification of phosphorus discovered?

226. Give the details of the process employed for the preparation of phosphorus from bone-ash. Represent all the reactions by equations.

227. In preparing phosphorus, sand is sometimes used along with charcoal for the final distillation. What is the advantage of this? Calculate the quantity of phosphorus which should be obtained from a ton of calcium

phosphate (*a*) using charcoal only, (*b*) using charcoal and sand.

228. The skeleton of a full-grown man weighs 24 pounds, and the bones contain 58 per cent. of calcium phosphate. Calculate the weight of phosphorus in the skeleton.

229. Why are preparations of bone-ash frequently employed as manures?

230. A piece of bone is heated (*a*) in a covered crucible, (*b*) in an open fire. Describe the substances obtained in each case, and state which would contain the larger proportion of phosphorus.

231. How is crude phosphorus purified? How is it cast into sticks?

232. How is amorphous phosphorus obtained on the large scale? How is it purified from traces of common phosphorus?

233. How may amorphous phosphorus be converted into common phosphorus, and *vice versâ*? How may these changes be shown on the small scale?

234. Compare the properties of the two varieties of phosphorus, and point out the differences between them.

235. How could you prove, in spite of the great differences in properties, that common and red phosphorus are modifications of the same element?

236. Two hundred and seven grammes of phosphorus pentoxide were obtained in each case by burning (*a*) phosphorus, (*b*) phosphine, in air. What weight of substance was used in each case?

237. What is the weight at N.T.P. of 1,234 litres of phosphorus vapour?

238. To what property of the element does phosphorus owe its name? Under what conditions does it lose this property?

239. Describe a process for the detection of phosphorus in cases of poisoning.

240. A manufacturer prepares phosphorus from 169 tons of bones containing 53·7 per cent. of calcium phosphate. How much phosphorus should he obtain, and how much sulphuric acid and carbon should be required for the process?

241. How has amorphous phosphorus been obtained in crystals, and what are the properties of this modification?

242. How may phosphorus be directly combined with oxygen, chlorine, hydrogen, and sulphur?

243. Which modification of phosphorus dissolves in carbon disulphide? What occurs when the solution is poured over a sheet of filter paper?

244. How are lucifer matches made, (*a*) using common phosphorus, (*b*) using amorphous phosphorus?

245. Give a short history of various means proposed for obtaining light, prior to the introduction of phosphorus matches.

246. Why is the end of an ordinary wooden match tipped with sulphur or stearine as well as phosphorus paste?

247. How may the so-called "safety matches" be kindled without bringing them in contact with amorphous phosphorus?

ARSENIC.

248. How does arsenic occur in nature? Name some of its ores, and state how the element is obtained from them?

249. How is the occasional presence of arsenic in hydrochloric acid explained? How may its presence be ascertained?

250. To what two substances is the name arsenic applied? Give the formula for each.

251. How has the density of arsenic vapour been ascertained, and what is peculiar about it?

252. What occurs when arsenic is heated (*a*) in oxygen, (*b*) in nitric acid, (*c*) in sulphuric acid?

253. How is arsenic prepared on the large scale from arsenical pyrites, and how is it purified?

254. How is arsenic obtained in the crystalline and amorphous modifications?

255. Discuss the various reasons which lead some chemists to class arsenic with the metals, and others with the non-metals.

256. Compare the properties of nitrogen, phosphorus, and arsenic, and give reasons for placing them in the same chemical group. Give the formulæ for the chlorides, oxides, sulphides, and hydrides of each.

257. Name poisonous and non-poisonous compounds of arsenic. Is the element itself poisonous?

258. 11·73 grains of arsenic trisulphide were obtained by analysis in a case of poisoning. To how much arsenic trioxide does this quantity correspond?

259. How much arsenic is contained on the walls of a room which is covered with 1,869 square feet of paper, each containing 0·78 gramme of Scheele's green?

HEXADS.

SULPHUR.

260. In what condition and in what localities does free sulphur occur in nature? Name the most important natural sulphides and sulphates.

261. What gases containing sulphur are sometimes found (*a*) in air, (*b*) dissolved in water?

262. With what minerals is native sulphur usually associated? How may this association be explained?

263. How is native sulphur extracted in Sicily? Give both the old and the improved process.

264. How is crude Sicilian sulphur purified in this country? Sketch the apparatus used.

265. How are flowers of sulphur and roll sulphur obtained? What is milk of sulphur, and how is it prepared?

266. Describe other methods employed on the large scale for obtaining sulphur.

267. Describe fully the changes which occur when sulphur is heated from the ordinary temperature to its boiling-point.

268. Describe the three modifications of sulphur, and state exactly how each is obtained.

269. Which forms of sulphur are obtained (*a*) by evaporating a solution of sulphur in carbon disulphide, (*b*) by adding an acid to calcium pentasulphide?

270. Describe an experiment in proof of the statement that sulphur sublimes at the ordinary temperature.

271. In what form is sulphur obtained when sublimed at a temperature of 100° in a current of air?

272. How may α sulphur be converted into β sulphur, and *vice versâ?*

273. What occurs when copper is dropped into boiling sulphur?

274. What gases are produced when sulphur burns (*a*) in air, (*b*) in oxygen, (*c*) in nitrous oxide?

275. How may sulphur be directly united (*a*) to carbon, (*b*) to chlorine?

276. What occurs in each case when sulphur is boiled (*a*) in nitric acid, (*b*) in sulphuric acid, (*c*) in caustic soda? Give equations.

277. Represent by equations the reactions which occur when iron pyrites is strongly heated (*a*) in presence of air, (*b*) in absence of air.

278. What weight of sulphur is contained in a litre of sulphuretted hydrogen, and in a litre of sulphur dioxide?

279. In what respect is the vapour density of sulphur abnormal? At what temperature is its vapour 32 times as heavy as hydrogen?

280. How could you obtain free sulphur from calcium sulphate?

281. Give other names for the substances called brimstone, galena, monoclinic sulphur, zinc blende, plastic sulphur, gypsum, and rhombic sulphur.

282. Write formulæ for several substances which show the analogy of oxygen and sulphur compounds.

SELENIUM.

283. By whom was the element selenium discovered? From what substance was it first prepared? What is the origin of the name?

284. From what substance and how is it generally prepared?

285. How are the amorphous and crystalline forms of selenium prepared?

286. Compare the properties of selenium with those of sulphur.

287. What occurs when selenium is heated in air or oxygen? Give the formula and properties of the substance formed.

288. What is the effect of light on the conducting power (for electricity) of selenium?

289. How may a solution of selenium be obtained?

290. What is peculiar about the vapour density of selenium?

TELLURIUM.

291. Name some naturally occurring compounds containing tellurium?

292. From what compound is tellurium usually prepared, and by what methods?

293. Compare the properties of tellurium with those of sulphur and selenium, and write the formulæ of several analogous compounds of each element.

294. What body is formed when tellurium is burned in oxygen? How may it be distinguished from the bodies produced by burning selenium and sulphur in oxygen?

AIR.

295. Who first determined the composition of the air? Describe fully the method he employed.

296. What are the two chief constituents of the air? By whom and when were they each discovered?

297. Name the bodies which are *always* present in the air in small quantities, and those which are *occasionally* present.

298. Describe a method for recognising with certainty each constituent of the atmosphere.

299. Is air a mechanical mixture or a chemical compound? Give reasons in support of your answer.

300. How do you account for the presence of carbon dioxide in the air? Why does the quantity remain nearly uniform?

301. What changes are produced in air by the breathing of animals and during the growth of plants?

302. A candle is burned in a closed bottle of air till it goes out, and a mouse is kept in a closed bottle of air

till it dies. Why does the candle go out and the mouse die, and what changes are produced in the air in each case?

303. Describe experiments to prove (*a*) that plants give out oxygen in daylight, (*b*) that animals breathe out carbon dioxide.

304. How do you account for the presence of each substance found in air only in small quantity?

305. How is the remarkable uniformity in the composition of the air explained?

306. Compare the action of air on plants and animals, (*a*) while they are alive, (*b*) after they are dead.

307. Describe several constantly occurring processes (*a*) which remove oxygen from the air, (*b*) which add carbon dioxide to it.

308. In what quantities are nitrogen, oxygen, carbon dioxide, and ammonia present in air?

309. How may phosphorus be used to demonstrate approximately the proportions of oxygen and nitrogen present in the air?

310. Describe fully how Dumas and Boussingault determined the composition of air by weight, and sketch the apparatus required for this purpose.

311. How may the composition of air be ascertained by means of the eudiometer?

312. In an analysis by Dumas and Boussingault's method the copper employed gained in weight 1·4904 gramme. Find the number of grains of air used and of nitrogen obtained.

313. Dr. Angus Smith found in 100 volumes of air, at the sea-shore in Scotland, 20·999 volumes of oxygen and in Manchester 20·960 volumes. How much sulphur would be required to unite with all the oxygen in one litre of each specimen?

314. How much air by volume is required for the complete combustion of 11·234 grammes of charcoal containing 85·89 per cent. carbon and 2·41 per cent. hydrogen?

315. Give two distinct *physical* processes for separating oxygen from air.

316. Lavoisier heated some mercury for several days in contact with 50 cubic inches of air at a temperature of 19° C. and under a pressure of 28 inches of mercury. At the close of the experiment, 42 cubic inches of gas remained unabsorbed, and 45 grains of mercuric oxide were obtained, which when heated yielded 41½ grains of

mercury and 7½ cubic inches of oxygen. How do these results agree with modern determinations?

317. Find the volume of nitrogen and oxygen present in air from the following results obtained by Bunsen in an analysis of the air at Marburg:—

	Vol.	Pressure at 0 °C.	Temp. C.	Vol. at 0° C. and 1 m. pressure.
Air employed .	882·2	0·5276	0·9	464·94
+ Hydrogen .	1053·8	0·6929	0·8	729·38
After explosion .	861·8	0·5084	0·7	437·83

Maximum temperature of air = − 1·5° C.
Minimum „ „ = − 1·25° C.
Barometer = 0·7423.

318. What is the action on air of (*a*) phosphorus, (*b*) potassium pyrogallate, at the ordinary temperature? How may the latter substance be used for the analysis of air?

319. Find the volume of air at 13° C. and 755 m.m. pressure required to burn a litre of carbon monoxide at the same temperature and pressure.

320. Find the composition of air from the following results obtained by Bunsen by absorption with potassium pyrogallate:—

	Vol.	Pressure.	Temp.	Vol. at 0° C. and 1 m. pressure.
Air employed .	368·9	0·5759	3·1° C.	210·08
After absorption	313·8	0·5358	3·1° C.	166 25

321. How would you analyse the air from a crowded theatre, and what ingredients would you expect to find in large quantity?

322. One hundred and twenty-nine c.c. of air at 15° C. and under a pressure of 753 m.m. mercury were contained in a cylinder standing over water. How much nitric oxide at the same temperature and pressure would be needed to combine with the oxygen?

323. During fogs in Manchester, Dr. Angus Smith found 6·79 volumes carbon dioxide in 10,000 volumes of air. How much calcium carbonate would be formed on shaking up a litre of such air with lime-water?

324. It has been found that air containing 250 volumes of carbon dioxide in 10,000 volumes will not support combustion. What is the percentage amount of oxygen, nitrogen, and carbon dioxide in such air?

325. A man inhales 18 cubic feet of air per hour. What weight of oxygen does he consume in 24 hours?

326. A man exhales 1,122 cubic inches of carbon dioxide per hour. How many men at the same rate would

be required to produce a ton of carbon dioxide in 24 hours?

327. In a well ventilated room the amount of carbon dioxide ought not to exceed 6 volumes in 10,000 of air. What weight does this correspond to per litre of air, and how much calcium carbonate would it precipitate from lime-water?

328. Give a short account of what is known about the solid matters, organic and inorganic, found floating in air? What impurities does rain-water extract from the air?

329. How did Pasteur prove that atmospheric dust contains particles capable of germination?

330. Mention various circumstances in which a putrescible liquid might be left in contact with air without giving rise to germination.

231. How may it be shown that air has weight? What is the weight of a litre of dry air at N.T.P.?

332. What is meant by the pressure of the atmosphere?

333. What is a barometer? Describe the simplest form of the instrument. What is the principle of the aneroid barometer?

334. What is meant by the "Torricellian vacuum?"

335. Why does the mercury in a barometer fall on ascending a mountain, and rise on descending?

336. Describe several experiments which prove that the atmosphere exerts a certain pressure.

337. Describe the construction and action of an ordinary air-pump, and of the instrument called Sprengel's pump.

COMPOUNDS OF NON-METALS WITH EACH OTHER.

COMPOUNDS OF HYDROGEN WITH OXYGEN.

WATER.

338. Describe the various kinds of naturally occurring water. Arrange them in order from the purest to the least pure.

339. Why is river-water more impure than rain-water? What does the latter contain?

340. Of what is pure water composed? Who discovered the composition of water? How and when was the discovery made?

341. Sketch the apparatus you would use to show the decomposition of water by the galvanic current.

342. Give all the ways you know for obtaining (*a*) hydrogen and (*b*) oxygen from water.

343. Cavendish exploded a mixture of 19,500 measures of oxygen with 37,000 of hydrogen. Which gas would remain after the explosion, and how much of it?

344. How could you show that water is produced by burning hydrogen in air or oxygen? Water is also produced when a candle or a gas-jet burns in air. How do you explain this?

345. What weight of hydrogen and of oxygen is contained in 100 lbs. of water?

346. A gas-holder contains 7½ litres of hydrogen at N.T.P., what volume of oxygen is required for its combustion, and what weight of water would result?

347. A strong glass flask containing 200 c.c. hydrogen and 100 c.c. oxygen weighs 417 grammes. An electric spark is passed through the mixed gases. What is the weight of the flask when cold?

348. How is the composition of water ascertained by means of the eudiometer? Give the details of the process.

349. After exploding a mixture of hydrogen and oxygen, 0·017 gramme water was obtained, and 11·5 c.c. hydrogen remained. The temperature was 15° C. and the pressure 760 m.m. Find the volume of the mixed gases.

350. What volume of steam is obtained by exploding a mixture of two volumes of hydrogen with one of oxygen?

351. Sketch Hofmann's apparatus for showing the volume of steam obtained by the explosion of a mixture of hydrogen (2 volumes) with oxygen (1 volume), and explain how it is used.

352. What happens when hydrogen is passed over heated copper oxide? Express the reaction by an equation.

353. Explain how the action of hydrogen on copper oxide may be used as a means of determining the composition of water.

354. Berzelius and Dulong heated 53·821 grammes copper oxide in contact with hydrogen. The residual copper weighed 42·989 grammes, and 12·197 grammes water were obtained. Calculate from these data the percentage composition of water.

355. Sketch Dumas' apparatus for the determination of the composition of water, and state the precautions he took to ensure the purity of the hydrogen employed.

356. As the result of numerous experiments Dumas found that 840·161 grammes of oxygen were required in the production of 945·439 grammes of water. Calculate from these data the percentage composition of water and the combining weight of oxygen.

357. One gramme of hydrogen is passed over 172 grammes of red-hot copper oxide. Find the weight of water produced, and the loss of weight of the copper oxide.

358. 53·5 c.c. of water were obtained by the action of hydrogen on heated copper oxide. Find the volume of hydrogen used, and of the oxygen with which it combined (both gases measured at N.T.P.).

359. What weight of iron sesquioxide, if heated in hydrogen, would be required to yield 12·7 grammes water, and what volume of hydrogen at N.T.P. would be used in the reaction?

360. Twenty litres of hydrogen measured at 15° C. and 754 m.m. are burned in air, and all the water produced is collected. Find the weight of the water and the volume of air required.

361. Give six equations to show that water is a frequent product of chemical reactions.

362. Explain each of the following terms—(*a*) water of crystallization, (*b*) hydrates, (*c*) deliquescent, (*d*) hygroscopic, (*e*) efflorescence, and (*f*) cryohydrates. Illustrate the meaning in each case by examples.

363. At what temperature is the density of water greatest? How may this be shown experimentally?

364. Starting with water at 15° C., explain the physical changes which occur (*a*) when it is heated to 100° C., (*b*) when it is cooled to 0° C.

365. How does the pressure of the atmosphere affect the temperature at which water boils?

366. What is the crystalline form of ice and snow? How may it be observed in each case?

367. What use is made of water in graduating a thermometer? Why is it chosen for this purpose?

368. At what temperatures does water boil and freeze respectively on the three thermometric scales in common use?

369. How may degrees on one scale be calculated into degrees on the others? What temperatures on the centigrade and Reaumur scales correspond to 15° Fahrenheit?

370. Sulphur melts at 115° C. and boils at 440° C. and sulphur dioxide boils at − 8° C. Calculate these temperatures on the two other scales.

371. What changes in bulk occur (*a*) when ice melts, (*b*) when water freezes, and (*c*) when water is heated?

372. Two thin glass tubes are filled with water and sealed up; one is placed in boiling water, the other in a freezing mixture. What occurs in each case?

373. Equal quantities of water at 79° C. and of ice are mixed together. What is the temperature of the mixture? Instead of ice, water at 0° C. is used, what is the temperature in this case?

374. Explain the term thermal unit.

375. Describe an experiment to show how the latent heat of steam may be ascertained.

376. What is meant by the term "tension of aqueous vapour," and how may it be measured?

377. In measuring a moist gas in a eudiometer, how would you ascertain the correction to be made for the tension of aqueous vapour?

378. Describe any experiment which proves that during the evaporation of water heat is absorbed.

379. What methods have been suggested for obtaining large quantities of ice artificially?

380. On what physical conditions does the amount of a gas capable of being dissolved by water, depend?

381. When water is decomposed by the galvanic current the oxygen measures rather less than half the hydrogen. How do you account for this?

382. Aqueous solutions of carbon dioxide, ammonia,

and oxygen are frozen. Is the gas expelled or retained at the moment of solidification?

383. On what physical conditions does the amount of a solid capable of being dissolved in water usually depend?

384. Describe the construction and use of an oxyhydrogen blowpipe. What is the temperature of the flame of an oxyhydrogen blowpipe, and how may it be used to fuse platinum?

385. If the water produced by burning hydrogen in oxygen be collected, is it pure or impure?

386. Classify the various kinds of impurities found in natural waters. Which impurities may be removed by filtration?

387. What do you understand by the terms "hard" and "soft," as applied to water?

388. How may the degree of hardness of a water be ascertained?

389. What produces the incrustation on the sides of a vessel in which large quantities of water have been boiled?

390. How may water be freed from all impurities and obtained chemically pure?

391. Name the impurities most commonly found in river-water, distinguishing the suspended, saline, and gaseous impurities.

392. How would you test a sample of water for chlorides and for sulphates?

393. How is the presence of lead in many waters accounted for, and how may its presence be detected?

394. Why is it of importance to determine the amount of organic matter present in water? Describe fully the processes of Frankland and of Wanklyn for this purpose.

395. How are the inorganic impurities in water detected and their amount estimated?

396. State briefly the considerations which would guide a chemist in determining whether or not a sample of water was suitable for domestic use.

397. Describe a process in use on the large scale for softening hard water?

398. What is the colour of perfectly pure water, and how may this be best seen?

399. Air usually contains 20·924 volumes oxygen and 79·076 volumes nitrogen. Air dissolved in pure water

consists of 34·91 volumes oxygen and 65·09 volumes nitrogen. How is this difference explained, and what is the action of air dissolved in impure water on the organic matter present?

400. Why is water called a neutral body?

401. Certain bodies when added to water cause a lowering of the temperature, others raise it. Give examples of each and explain the cause.

402. What is the action of each of the following bodies on water, (*a*) lime, (*b*) sulphuric acid, (*c*) phosphorus trichloride, (*d*) soda, (*e*) phosphorus pentoxide?

403. What occurs when anhydrides are added to water? Give examples.

HYDROGEN DIOXIDE.

404. By whom and when was hydrogen dioxide first prepared? Does it occur in nature? if so, how? By what other names is the substance known?

405. How is hydrogen dioxide prepared? Give two methods. Can it be obtained in the pure state?

406. What are the properties of hydrogen dioxide, and what occurs when it is heated?

407. Give examples of reactions in which hydrogen dioxide (*a*) oxidizes, (*b*) deoxidizes (reduces).

408. Give various reactions for the detection of hydrogen dioxide. Which test would you apply to detect extremely small quantities?

409. Explain the action of hydrogen dioxide on (*a*) silver oxide, (*b*) manganese dioxide, (*c*) ozone.

410. What is the action of hydrogen dioxide on each of the following bodies? (*a*) potassium iodide, (*b*) lead sulphide, (*c*) potassium permanganate, (*d*) potassium chromate, (*e*) charcoal, (*f*) finely divided platinum.

411. Represent by equations the action of hydrogen dioxide on (*a*) sulphur dioxide, (*b*) nitrogen tetroxide, (*c*) barium monoxide.

412. How may hydrogen dioxide and ozone be detected as products of the combustion of hydrogen in air?

413. Hydrogen dioxide is sometimes used for cleaning old oil paintings. What is its action when used for this purpose?

COMPOUNDS OF CHLORINE.

414. How does hydrochloric acid occur in nature, and by what other names is it known?

415. How may hydrochloric acid be prepared from its elements? Describe different ways of effecting the union.

416. Starting with common salt, how could you prepare hydrochloric acid?

417. A burning jet of hydrogen is plunged into a jar of chlorine; what occurs, and what property does the product possess which distinguishes it from both hydrogen and chlorine?

418. Using only chlorine and water, how may hydrochloric acid be prepared?

419. What occurs when a galvanic current passes through a strong solution of hydrochloric acid, previously saturated with chlorine?

420. In what proportions by volume and weight do hydrogen and chlorine unite?

421. What volume of hydrogen at N.T.P. is needed to unite with 1 gramme of chlorine?

422. A cylinder contains a mixture of equal volumes of hydrogen and chlorine, it is opened under a solution of potassium iodide. State what occurs, and express the reaction by an equation.

423. Describe various methods which may be used to ascertain the proportion of hydrogen and chlorine contained in hydrochloric acid gas.

424. Give several reactions to show the tendency of chlorine to unite with combined hydrogen.

425. How much hydrochloric acid must be decomposed to yield enough chlorine to liberate 2·34 grammes of iodine from potassium iodide?

426. A solution of hydrochloric acid required 10·67 grammes of silver nitrate to precipitate it completely. Find the volume of hydrochloric acid (at N.T.P.) in solution.

427. Sketch the apparatus required for preparing small quantities of pure hydrochloric acid, and calculate the quantities of common salt and sulphuric acid required to

saturate a litre of water with the gas (water at 15° C. dissolves 450 times its bulk of the gas).

428. How is hydrochloric acid prepared on the large scale? Sketch the plant required.

429. What impurities are usually present in commercial hydrochloric acid, and how is their presence accounted for?

430. At 12° C. and 760 m.m. pressure 1 gramme water absorbs 0·762 gramme hydrochloric acid. Find the quantity of salt and sulphuric acid required to yield a ton of hydrochloric acid at the same temperature and pressure.

431. What important fact was ascertained by Roscoe and Dittmar on distilling aqueous solutions of hydrochloric acid at different pressures? How may this property be applied to the preparation of standard solutions of the acid?

432. What occurs when a current of hydrochloric acid is passed over (*a*) sodium, (*b*) manganese dioxide, (*c*) iron?

433. How is iodine chloride prepared, and what are its properties?

434. If a current of chlorine be led into solution of

potassium iodide mixed with starch, the liquid at first becomes blue, but by the continued passage of the gas it becomes colourless. Explain this.

535. Give the names and formulæ of the oxides of chlorine, and state how each is prepared.

436. What occurs when a red-hot wire is placed in a tube filled with chlorine tetroxide?

437. Give several illustrations of the powerful oxidizing action of chlorine tetroxide?

438. What is euchlorine, and how is it prepared?

439. Write the names and formulæ of the compounds containing chlorine, hydrogen, and oxygen.

440. Give three distinct methods for the preparation of hypochlorous acid. What are the properties of the substance?

441. Compare the bleaching action of chlorine with that of hypochlorous acid, and explain each by equations.

442. What happens when lime is thrown into a cylinder containing chlorine? What is the common name of the substance produced, and how is it obtained on the large scale?

443. Express by equations the action on bleaching

powder of (*a*) sulphuric acid, (*b*) nitric acid, (*c*) hydrochloric acid.

444. What occurs when a stream of chlorine is passed through (*a*) a hot solution of potash, (*b*) a cold solution of potash? Express each reaction by an equation.

445. How is potassium chlorate prepared on the large scale? How would you react on calcium chlorate so as to obtain potassium chlorate?

446. How is potassium chlorate separated from potassium chloride when both are present in a solution? By what tests could you distinguish the two salts?

447. How is potassium perchlorate obtained from the chlorate? Give an equation.

448. A certain weight of potassium chlorate is heated for the preparation of perchlorate; 10 litres of oxygen at N.T.P. are obtained. Find the weight of chlorate used and of perchlorate obtained.

449. How did Roscoe obtain pure perchloric acid, and what are its properties?

450. What compound does perchloric acid form with water, and how is it obtained? How is its formation explained?

451. What occurs when perchloric acid is added to (*a*) water, (*b*) charcoal?

452. Calculate the composition of potassium perchlorate from the following experimental data obtained by Roscoe. 0·9915 gramme of the pure salt lost on heating 0·4570 gramme, the residue required 0·7683 gramme of silver for complete precipitation. Also, 0·3165 gramme of the salt when treated with sulphuric acid yielded 0·201 gramme potassium sulphate.

453. How could you distinguish (*a*) a solution of chlorine from one of hypochlorous acid, (*b*) a solution of potassium chlorate from one of potassium perchlorate?

454. What quantities respectively of potassium chlorate and potassium perchlorate would be needed to furnish when heated a litre of oxygen at N.T.P.?

455. Starting with potassium chlorate, how could you obtain the chlorates of sodium and barium?

COMPOUNDS OF BROMINE.

456. Describe different methods for combining bromine directly with hydrogen.

457. What weight of bromine and of hydrogen does a litre of hydrobromic acid gas at N.T.P. contain?

458. What happens when potassium bromide is dropped into (*a*) sulphuric acid, (*b*) phosphoric acid?

459. Express by equations the action of hydrobromic acid on sulphuric acid, and of bromine water on sulphuretted hydrogen.

460. If a hydrogen flame be surrounded with bromine vapour what occurs? If coal-gas be substituted for hydrogen what occurs?

461. What is the action of phosphorus on chlorine, on bromine, and on iodine, and what is the action of water on each of the products?

462. Describe fully how you would fill a cylinder with

dry hydrobromic acid, and how you would show that it is soluble in water and acid.

463. A cylinder standing over mercury is half filled with sulphuretted hydrogen; a thin glass bulb containing bromine is passed up and then broken in the gas. What reaction occurs, and how does it affect the volume of gas in the cylinder?

464. How may the composition of hydrobromic acid be ascertained?

465. Express by equations the reactions which occur when hydrobromic acid is added to (*a*) zinc, (*b*) silver nitrate, (*c*) chlorine, (*d*) manganese dioxide.

466. Aqueous solution of hydrobromic acid having a specific gravity of 1·515 has been found to contain 49·8 per cent. of the gas. How much silver nitrate is needed to precipitate 100 c.c. of the solution?

467. Do chlorine and bromine unite together? How could you distinguish between a solution of chlorine in bromine and a compound of the two elements?

468. No compound of bromine with oxygen is at present known. Suggest methods for attempting to prepare such a compound.

469. Give different methods for the preparation of

hypobromous acid. How would you distinguish it from hypochlorous acid?

470. What occurs when bromine is left in contact with slaked lime, and what is the action of (*a*) hydrochloric acid, (*b*) nitric acid, on the product?

471. Express by equations the actions of (*a*) chlorine on bromine water, (*b*) bromine on caustic potash, (*c*) bromine water on silver bromate.

472. What occurs when heat is applied to (*a*) bromic acid, (*b*) potassium bromate?

473. How is perbromic acid obtained? Compare its properties with those of perchloric acid.

COMPOUNDS OF IODINE.

474. Do iodine and hydrogen combine together directly, and if so, how?

475. State fully what occurs when strong sulphuric acid is dropped on potassium iodide.

476. How is hydriodic acid usually prepared? How would you obtain (*a*) the dry gas, (*b*) a saturated aqueous solution of it?

477. What occurs when a current of sulphuretted hydrogen is passed through a solution of iodine?

478. What are the properties of hydriodic acid, and what occurs when it is strongly heated?

479. How many cubic centimetres of hydriodic acid at N.T.P. are required to weigh the same as 1,000 of hydrogen?

480. What is the action on hydriodic acid of (*a*) chlorine, (*b*) bromine, (*c*) iodine, (*d*) sulphur dioxide?

481. What volume of hydriodic acid at N.T.P. contains 1 gramme of iodine, and how could it be extracted?

482. Illustrate the action of hydriodic acid on organic compounds by explaining how it acts on tartaric acid and on glycerine.

483. Name six soluble and six insoluble iodides, and state what is the action of chlorine on each.

484. How could you detect each of the constituents in a mixture of potassium chloride, bromide, and iodide?

485. Give a short account of the compounds of iodine with chlorine and with bromine.

486. Find the percentage composition and formulæ of the chlorides of iodine, from the following data :—

(*a*) 0·521 gramme chloride contained 0·283 gramme iodine and 0·238 gramme chlorine.

(*b*) 0·732 gramme chloride contained 0·574 gramme iodine and 0·158 gramme chlorine.

487. What evidence is there for supposing the existence of hypoiodous acid?

488. How is iodic acid obtained, and what occurs when it is heated?

489. What is the action on iodine of (*a*) nitric acid, (*b*) caustic potash?

490. What weight of iodic acid contains 1·567 gramme iodine, and by what reactions could it be obtained from it?

491. How are periodic acid and the periodates respectively prepared?

492. Write the formulæ of all the known compounds of the halogens with (*a*) hydrogen, (*b*) oxygen, (*c*) hydrogen and oxygen.

493. Chlorine is passed into water containing 23 grammes iodine in suspension. What volume at N.T.P. is required to convert all the iodine into iodic acid?

COMPOUNDS OF FLUORINE.

494. What is the action of sulphuric acid on calcium fluoride, and of heat on hydrogen potassium fluoride? Give equations.

495. What is the difference between the action of anhydrous and dilute hydrofluoric acid on (*a*) glass, (*b*) gutta-percha?

496. What is the action of hydrofluoric acid on silica and of the product on water? State also the action of the acid on glass. Give equations.

497. A weighed piece of glass is acted on by hydrofluoric acid. After the action it is found to have lost 1·347 gramme, how much hydrofluoric acid is needed to produce this result?

498. Gore heated 16·4 grains silver fluoride in contact with 6 cubic inches pure hydrogen and obtained 14·5 cubic inches hydrofluoric acid measured at 200° F. Find the volume of hydrogen which had combined

with fluorine, and state what conclusions you draw as to the composition and density of hydrofluoric acid.

499. 4·387 grammes meerschaum ($Si_3O_{10}H_4Mg_2$) are heated with hydrofluoric acid till no further reaction occurs. How much silicon tetrafluoride should be formed?

500. How is hydrofluoric acid used in the preparation of eudiometers?

501. How would you obtain the fluorides of silver, barium, and potassium? Which of these salts dissolves in water?

502. Give the formulæ of potassium borofluoride and of potassium silicofluoride, and state how each of these substances is obtained.

503. How is hydrofluosilicic acid prepared? Sketch the apparatus required for its preparation, and give its action on solutions of potassium and barium salts.

COMPOUNDS OF BORON.

504. How is boron hydride prepared? What are its properties, and what occurs when it burns in air?

505. Compare the properties of boron hydride with those of the hydrides of silicon, phosphorus, and arsenic.

506. How may the composition of boron hydride be ascertained?

507. How is the chloride of boron prepared, and what is its formula? What is its action when heated with (*a*) sodium, (*b*) magnesium, (*c*) zinc?

508. What occurs when boron trichloride is placed in water? Give an equation and name another chloride which reacts similarly on water.

509. A compound of boron trichloride with ammonia contains 14·68 per cent. of nitrogen, find its formula and state how it is obtained.

510. Give the formulæ and modes of preparation of the compounds of boron with bromine and fluorine.

511. Express by equations the action of (*a*) water on boron fluoride, (*b*) heat on potassium borofluoride.

512. What is the formula of boric anhydride? What acid is formed by its union with water?

513. What loss of weight would 2·189 grammes of boric acid suffer if heated till free from water?

514. How does boric acid occur in nature, and how is the pure acid obtained from the natural source?

515. What is borax, and how is boric acid obtained from it? How is the presence of boric acid in a mixture ascertained?

516. Draw graphic formulæ for boric and metaboric acids, also for boron trioxide, and state how the first must be treated so as to yield the others.

517. How may boron be combined with nitrogen and with sulphur? Describe the two products and give their formulæ.

COMPOUNDS OF CARBON.

518. What bodies are called hydrocarbons? Give the names and formulæ of a few.

519. Name the chief hydrocarbons contained in coal-gas. To what does it owe its illuminating power?

520. How is coal-gas made and purified? Give a short account of its discovery and introduction as a source of light.

521. Name the chief products obtained by the destructive distillation of cannel coal, and state how the coal-gas is separated from the others.

522. Name all the elements usually present in coal-gas, and state how they are supposed to be combined.

523. A sample of Wigan cannel coal contains 5·71 per cent. hydrogen. If coal-gas made from this contained all the hydrogen as marsh-gas, find the volume of the latter which should be obtained from a kilogramme of the coal.

524. A sample of coal-gas contains in 100 volumes 45·58 hydrogen, 34·90 marsh-gas, 6·64 carbonic oxide. Find the volume and weight of carbon dioxide and water produced when a litre of it is burned.

525. What compounds are given off when a paraffin candle and coal-gas are separately burned in air?

526. Explain the construction of a Bunsen lamp. Why does the flame not blacken a cold porcelain plate held over it?

527. A soap bubble inflated with coal-gas is allowed to ascend through the air into a bell-jar filled with hydrogen. What occurs when it reaches the hydrogen?

528. Explain the principle and construction of the Davy lamp.

529. Describe experiments which show that the inner portion of a candle or gas-flame contains unburnt gases.

530. How may carbon be directly combined (*a*) with hydrogen, (*b*) with oxygen?

531. Give various methods for the preparation of carbon monoxide. Represent the reactions by equations.

532. What weight of crystallized oxalic acid is needed

to furnish 17 grammes of carbon monoxide, and what volume of carbon dioxide at N.T.P. would be likewise obtained?

533. How may carbon monoxide be obtained from carbon dioxide, and *vice versâ?*

534. Explain the production of carbon monoxide when coals burn in an ordinary fireplace.

535. How may carbon dioxide be separated from carbon monoxide and *vice versâ?*

536. One gramme of carbon is heated in contact with 119 litres of carbon dioxide at N.T.P. What reaction occurs, and what is the volume after the experiment?

537. You are required to prepare (*a*) pure carbon dioxide, (*b*) pure carbon monoxide, using only carbon and oxygen. How will you proceed in each case?

538. What volume of oxygen when exploded with 120 c.c. carbon monoxide is just sufficient to combine with it, and what volume of carbon dioxide is produced?

539. What weight of carbon is contained (*a*) in a litre of carbon monoxide, (*b*) in a litre of carbon dioxide, and how could you obtain it from each gas?

540. Give two distinct ways for obtaining carbon dioxide from marble (carbonate of lime), and describe the properties of the gas.

541. What occurs when carbon dioxide is (*a*) heated with potassium, (*b*) shaken up with litmus solution, (*c*) allowed to pass through solution of caustic potash?

542. What is lime-water, and how is it made? What happens when carbon dioxide is led into it (*a*) in small quantity, (*b*) in excess? Express all the reactions by equations.

543. How is carbon dioxide obtained as a liquid and as a solid?

544. Explain the term "temporary hardness" applied to water. What occurs when such water is boiled?

545. A diamond weighing 0·1247 gramme and containing 0·03 per cent. of ash is burned in oxygen. Find the volume and weight of carbon dioxide produced.

546. A closed room has a capacity of 27 cubic metres. Find the weight of oxygen, nitrogen, and carbon dioxide it contains, before and after a kilogramme of pure carbon is burned in it.

547. Dumas and Stas found that 300·02 parts of diamond combine with 800 parts of oxygen to form

carbon dioxide. Calculate from these data the combining weight of carbon.

548. What are petrefactions, and how have they been formed?

549. What is the formula for carbonic acid? What occurs when its aqueous solution is (*a*) boiled, (*b*) added to litmus solution, (*c*) added to lime water?

550. How did Faraday first obtain carbon dioxide in the liquid state? What is meant by the "critical point" of a gas? How did Andrews ascertain the critical point of carbon dioxide?

551. How does liquid carbon dioxide occur in nature, and how has this been ascertained?

552. A piece of Iceland spar lost when heated 1·236 gramme. Find its weight, and the volume of carbon dioxide evolved, measured at 13° C. and 755 m.m. pressure.

553. How may carbon be combined with sulphur, and what are the properties of the product?

554. How much carbon and sulphur are contained in a litre of carbon disulphide (S. G. = 1·292), and how could they be obtained from it?

COMPOUNDS OF SILICON.

555. How did Buff and Wöhler first obtain silicon hydride? How may the substance be obtained in the pure state?

556. What are the properties of silicon hydride, and how is it most readily prepared?

557. How is silicon tetrachloride prepared, and what is its action on water?

558. Represent by an equation the reaction which occurs when a mixture of silica and fluor spar is heated with sulphuric acid. What happens when the product is passed into water?

559. Name six forms of silica found in nature, and state the composition of the following bodies—felspar, opal, clay, serpentine, garnet, talc, orthoclase, and agate.

560. In what organic bodies does silica occur, and how may its presence in water be ascertained?

561. Suggest a process for obtaining oxygen from silica.

562. What are zeolites, and what is the action of hydrochloric acid on them?

563. What is the action (if any) on silica of (*a*) sulphuric acid, (*b*) potash, (*c*) hydrofluoric acid, (*d*) sodium carbonate (heated till fused), (*e*) chlorine?

564. How is the quantity of silica in a sample of water usually determined?

565. How would you make a complete quantitative analysis of potash felspar?

566. Describe Graham's researches which resulted in the discovery of ortho-silicic acid.

567. What is the substance termed soluble glass, and what is the action of hydrochloric acid on a strong and on a weak solution of it?

568. Explain the term "dialysis," "colloids," "crystalloids." Classify the following substances into colloids and crystalloids—common salt, sugar, starch, arsenious acid, glue, nitre, and gum.

COMPOUNDS OF NITROGEN.

569. Give a short account of the history and natural occurrence of ammonia.

570. How may ammonia be prepared (*a*) by synthesis, (*b*) from nitric acid, (*c*) from ammonium salts?

571. What is the chief commercial source of ammonia compounds? Describe fully the preparation of sal-ammoniac on the large scale.

572. Represent by equations the action of potash and of quick-lime on ammonium chloride. How much quick-lime is necessary to decompose 14·7 grammes of ammonium chloride?

573. A litre of ammonia gas at N.T.P. weighs 0·7619 gramme. Find how much heavier it is than hydrogen, and how much lighter than air.

574. How was ammonia gas first liquefied by Faraday? Describe Carré's apparatus for obtaining ice artificially by means of liquid ammonia.

575. Is ammonia a combustible gas? Describe experiments in support of your answer.

576. What occurs when ammonia gas is passed (*a*) over heated potassium, (*b*) into hydrochloric acid, (*c*) over red-hot fragments of porcelain?

577. One gramme of water at 14° C. and under a pressure of 760 m.m. absorbs 0·612 gramme ammonia. What weight of ammonium chloride and of lime must be heated to saturate with ammonia a kilogramme of water at the same temperature and pressure?

578. Electric sparks are passed through 79 c.c. of ammonia gas. What change in volume occurs, and what is the composition by volume of the residue?

579. What volume of ammonia gas at N.T.P. should be obtained by heating 139 grammes ammonium chloride with quick-lime?

580. What is the weight of 35 litres ammonia gas at N.T.P.? When 35 litres of hydrochloric acid gas are mixed with it, what occurs, and what is the weight of the product?

581. Under what circumstances does ammonia burn, and what are the products of combustion? Find the

volume and weight of the products obtained by burning 129 c.c. of the gas at N.T.P.

582. An alkaline solution (which you are told is either potash or ammonia) is saturated with hydrochloric acid and evaporated to dryness. How would you ascertain (*a*) by physical tests, (*b*) by chemical tests, the nature of the product?

583. A gaseous mixture contains ammonia and hydrogen, how can the hydrogen be obtained entirely free from ammonia?

584. How can ammonia be obtained from nitric acid, and what weight of nitric acid would be necessary to yield 179 c.c. measured at 13° C. and under a pressure of 754 m.m.?

585. What volumes of hydrogen and nitrogen are contained in 123 grammes of ammonia?

586. Describe fully Hofmann's method of ascertaining the composition of ammonia, by the action of chlorine on the gas.

587. Seventy-five grammes of a solution containing 21 per cent. of ammonia are added to 134 grammes pure nitric acid. Find the weight of ammonium nitrate produced, and of nitric acid remaining unsaturated.

588. What occurs when ammonia is added to (*a*) copper sulphate solution, (*b*) silver chloride, (*c*) ferric chloride solution, (*d*) silver oxide, (*e*) zinc sulphate solution, (*f*) manganese chloride solution?

589. How is ammonia usually tested for and estimated quantitatively? What is Nessler's test, and how is it used?

590. How is chloride of nitrogen prepared, and what are its properties? Name the chemists who discovered it and investigated its properties. What is the most probable formula for the compound?

591. How is iodide of nitrogen obtained? What views are held with regard to its composition?

592. How may nitrogen be directly combined with oxygen? Sketch the apparatus used to show the union.

593. Give a list of all the compounds of nitrogen and oxygen which have been obtained. Give also the formula and density of each, and state whether they are solid, liquid, or gaseous at the ordinary temperature.

594. Electric sparks are passed through a globe filled with air. Ammonia solution is then added to the globe and the product evaporated to dryness. State fully what occurs, and name the oxide of nitrogen which would be obtained on heating the residue.

595. What occurs when ammonia solution is added to nitric acid? What occurs when the product is heated? Give equation for both reactions.

596. Represent by equations the reactions caused by heating (*a*) ammonium nitrite, (*b*) ammonium nitrate.

597. How is nitrous oxide prepared and collected, and what are its properties?

598. A glowing taper was rekindled when placed in a jar which contained either nitrous oxide or oxygen. How could you ascertain with certainty which gas was present?

599. If 100 litres of nitrous oxide at N.T.P. be decomposed into free oxygen and nitrogen, what increase in bulk will occur?

600. How much phosphorus could be burned in 100 litres of nitrous oxide at N.T.P.?

601. Twenty grammes of nitrous oxide were obtained by heating ammonium nitrate, how much of the salt was used?

602. Point out the resemblances between nitrous oxide and oxygen, and state how they may be distinguished (*a*) by chemical tests, (*b*) by physical tests.

603. Write an account of the preparation and properties of nitric oxide.

604. What is the weight of 5 litres of nitric oxide at N.T.P.? What volume at N.T.P. will 5 grammes of the gas occupy?

605. How can it be proved that nitrous oxide contains its own volume of nitrogen, and nitric oxide half its volume of nitrogen?

606. If a gas-holder contains when full 25 grammes of oxygen, what weights of nitrous and of nitric oxides will it hold?

607. What volume of nitrogen will be left in each case, by heating potassium in contact with 17 grammes of nitrous and nitric oxides?

608. What occurs when nitric oxide is passed over red-hot copper, and how much will the copper gain in weight when 11 litres of the gas at N.T.P. are passed over it?

609. Air is passed into 1 litre of nitric oxide standing over water, so long as brown fumes are formed. What gas remains after these have dissolved, and what is its volume?

610. Answer the previous question for oxygen instead of air.

611. Under what circumstances does nitric oxide

(*a*) extinguish burning phosphorus, (*b*) support its combustion?

612. What happens when nitric oxide is passed into solution of ferrous sulphate?

613. What impurities are present in nitric oxide prepared by the action of nitric acid on copper? How is the gas obtained quite pure?

614. Give different methods for obtaining nitrogen trioxide, and state what occurs when it is added to water.

615. What substance is produced when potassium nitrate is heated, and what is the action of dilute acids on the product?

616. What volume of oxygen must be added to 1234 c.c. of nitric oxide, so as to convert it into nitrogen trioxide?

617. What is the probable composition of a mixture produced by adding 3 volumes of dry nitric oxide to 1 volume of dry oxygen?

618. How may nitrites be detected in presence of nitrates?

619. What occurs when dry lead nitrate is heated? Give an equation for the reaction, and describe the oxide of nitrogen thus obtained.

620. Why are nitrogen dioxide and tetroxide represented by the formulæ NO and NO_2 respectively, and not by N_2O_2 and N_2O_4?

621. What is the action on nitrogen tetroxide of small and large quantities of water?

622. How is nitrogen pentoxide obtained, and how is it related to nitric acid?

623. What is the action of phosphorus pentoxide on nitric acid, and how may nitric acid be obtained from the product?

624. What naturally occurring compounds may be used for the preparation of nitric acid? How do they generally occur, and how is their formation accounted for?

625. How is nitric acid usually prepared (*a*) on the small scale, (*b*) on the large scale? What impurities are generally present in the commercial acid?

626. How may nitric acid be obtained starting with hydrogen, oxygen, and nitrogen?

627. How much sulphuric acid is needed to react on 129 tons of nitre so as to obtain nitric acid, and how much of the latter should be got from this weight of the salt?

628. What are the best tests for nitric acid, and how may these tests be applied to the detection of nitrates?

629. Starting with nitric acid, how may each of the oxides and acids of nitrogen be obtained? Give equations.

630. Name all the bodies which can be obtained by the action of nitric acid of different strengths on zinc. Explain the formation of each and give equations.

631. What is the action of strong nitric acid on (*a*) sulphur, (*b*) mercury, (*c*) sulphur dioxide, (*e*) tin, (*f*) phosphorus?

632. How much pure nitric acid is present in 159 tons of nitric acid, 100 grammes of which neutralize 44·3 grammes pure caustic potash?

633. Name four metals which are not acted on by nitric acid, and state how solutions of each may be obtained.

634. What is aqua regia? What substances are required to prepare it, and what gases does it contain?

635. What is the formula of hyponitrous acid, and how is it related to nitrous and nitric acids? How are its salts obtained?

COMPOUNDS OF PHOSPHORUS.

636. Give different ways for the preparation of phosphine, and describe its properties. Can it be prepared by direct union of its elements, and if so, how?

637. What occurs when spontaneously inflammable phosphine is left in contact with (*a*) charcoal, (*b*) sulphur, (*c*) potassium permanganate solution?

638. How is phosphine obtained quite pure? What change in volume occurs when electric sparks are passed through the pure gas?

639. Under what circumstances is phosphine spontaneously inflammable? How may the gas be made to lose and regain the property of inflaming spontaneously?

640. Compare the properties of phosphine with those of ammonia. What is the action of each on silver nitrate solution? Give equations.

641. How may phosphine be combined with hydriodic

acid, what is the formula of the compound produced, and how may it be best obtained in quantity?

642. How are the liquid and solid hydrogen phosphides prepared, and what are their properties? Give the formula for each.

643. How much oxygen, by weight and volume, is required to burn completely 179 c.c. of phosphine?

644. Twenty-seven c.c. of phosphine are added to 39 c.c. of hydriodic acid. What occurs? Give the weight of the solid and the volume of the gaseous product.

645. How are the trichloride and pentachloride of phosphorus respectively obtained? How may the trichloride be obtained from the pentachloride and *vice versâ?*

646. What is the action of phosphorus trichloride on each of the following bodies? (*a*) water, (*b*) sulphur trioxide, (*c*) sulphuric acid, (*d*) alcohol, (*e*) sulphuretted hydrogen, (*f*) acetic acid. Give equations.

647. What is the action of phosphorus pentachloride on (*a*) water in small quantity, (*b*) excess of water? Give also its action on all the other substances mentioned in the previous question. Give equations.

648 What is the formula of the substance called phosphorus oxychloride? Give various reactions for obtaining it, and state its action on water and on alcohol.

649. How are the bromide and iodide of phosphorus obtained, and what is the action of each on water?

650. Give the formulæ of the two fluorides of phosphorus, and state how each is prepared.

651 What is the composition of the white fumes formed when a piece of dry phosphorus is exposed to air? How is the substance obtained in quantity?

652. Name the two oxides of phosphorus, give their formulæ, and state how they are prepared. Represent by equations the action of water on each.

653. Nine grammes of phosphorus pentoxide exposed to air gained 2·76 grammes. Find the percentage composition of the product so obtained.

654. How could you obtain phosphorus from phosphorous pentoxide?

655. How much water must be added to 187 grammes of phosphoric anhydride so as to convert it into phosphoric acid?

656. Give the names, formulæ, and percentage composition of the three acids of phosphorus.

657. What happens when phosphorus is heated with (*a*) solution of potash, (*b*) solution of barium hydrate? Give equations.

658. How is hypophosphorous acid prepared? What occurs when it is (*a*) heated, (*b*) added to copper sulphate solution, (*c*) added to silver nitrate solution? Give equations.

659. Give the constitutional formula of hypophosphorous acid, and the formulæ of its potassium and barium salts.

660. Give two different methods for obtaining phosphorous acid, and state what occurs when it is heated. Give equations.

661. Give the volume of the gaseous product at N.T.P. which should be obtained by heating 79 grammes of phosphorous acid.

662. Write the formulæ of the sodium salts of hypophosphorous, phosphorous, and phosphoric acids.

663. Give different methods which may be used for preparing ortho-phosphoric acid.

664. What changes occur when phosphoric acid is heated (*a*) to 215° C., (*b*) to a red heat? Give the formula of each product, and express the reactions by equations.

665. How may orthophosphoric acid be prepared from bone-ash?

666. What is meant by saying that phosphoric acid is tribasic? Give the formulæ of the sodium orthophosphates, and state how they are prepared.

667. How much phosphoric acid should be obtained by the oxidation of 1796 grammes of phosphorus with nitric acid?

668. What is the composition of the salt obtained by adding sodium carbonate to orthophosphoric acid till the latter ceases to redden litmus-paper? What salts are obtained by adding to this one, (*a*) phosphoric acid, (*b*) caustic soda?

669. Give the reaction of silver nitrate on each of the salts obtained by the processes mentioned in the previous question.

670. What is microcosmic salt, and how is it prepared? What occurs when it is heated? Give an equation.

671. When common sodium phosphate is heated till it ceases to lose water, what is the composition of the

residue? What weight of residue should be obtained by heating 193 grammes of the salt?

672. By what reactions could you distinguish normal from common sodium phosphate, and both these salts from sodium meta- and pyrophosphates?

673. Solution of magnesium sulphate is added to sodium phosphate in presence of ammonia and ammonium chloride, what substance is precipitated? What salt is obtained by igniting the precipitate?

674. To what substance is the name "glacial phosphoric acid" given, and how is it related to the orthophosphoric acid?

675. Give a short account of the phosphates obtained by Fleitmann and Henneberg, and show how they are related to the other phosphates.

676. Give a short account of the different sulphides of phosphorus.

COMPOUNDS OF ARSENIC.

677. Who discovered hydride of arsenic (arsine), and how did he obtain it? Give other methods.

678. What occurs when an electric current is passed through a solution of arsenious acid? To what purpose has this reaction been applied by Bloxam?

679. What occurs when arsine is (*a*) passed through a red-hot tube, (*b*) passed through solution of silver nitrate, (*c*) passed over sulphur exposed to sunlight, (*d*) passed over heated copper oxide?

680. Give equations to express the reactions which occur when phosphine and arsine are separately led into solution of silver nitrate.

681. Describe the tests for arsenic known as "Marsh's test" and "Reinsch's test."

682. What occurs when arsine burns (*a*) in air, (*b*) in oxygen? How much oxygen is required for the complete combustion of 173 c.c. at N.T.P.?

683. Express by equations the reactions which occur

when arsine (*a*) is passed through solution of potassium permanganate, (*b*) is mixed with chlorine.

684. What is the formula of the only known chloride of arsenic, and how is the substance obtained?

685. What is the action of arsenic chloride (*a*) on water, (*b*) on ammonia?

686. In what different modifications does arsenic trioxide occur, and how may each be obtained?

687. What weight of the oxide is formed by burning 3·567 grammes arsenic in a current of oxygen?

688. How may arsenic trioxide be obtained in octahedral and in rhombic crystals?

689. What molecular formula would you assign to arsenic trioxide knowing that its density is 13·85 (air = 1)?

690. How is arsenic pentoxide obtained, and what occurs when it is heated to a high temperature?

691. What occurs when arsenic trioxide is heated in contact (*a*) with charcoal, (*b*) with acetates?

692. Write the formulæ of the hydrides, chlorides, oxides, and acids of phosphorus and arsenic. In what respect do the pyro- and meta-acids of the two elements

693. What is the action of arsenious acid on (*a*) chlorine, (*b*) iodine, (*c*) bleaching powder? Give equations for the reactions.

694. Ten grammes bleaching powder containing 34·7 per cent. of available chlorine are dissolved in 1 litre of water. How much arsenic trioxide dissolved in potash will be required to saturate 100 c.c. of the bleaching powder solution?

695. What is the best antidote to arsenic poisoning? Explain its action.

696. What is Scheele's green, and how is it prepared on the large scale? What percentage of arsenic does it contain?

697. How is arsenic acid obtained? By what tests is it distinguished from arsenious acid?

698. Give the formulæ of the silver and potassium salts of arsenious and arsenic acids.

699. How is the presence of arsenic ascertained in cases of poisoning, and how is the amount of the poison estimated?

700. Give a short account of the compounds of arsenic with sulphur and phosphorus. What is the composition of realgar and of orpiment?

COMPOUNDS OF SULPHUR.

701. Describe different methods for directly combining hydrogen with sulphur, and give the formula of the sulphide produced.

702. What volume of hydrogen at N.T.P. is required to combine with 1 gramme of sulphur?

703. How does sulphuretted hydrogen occur in nature, and how may its presence be detected?

704. How do you account for the occasional presence of sulphuretted hydrogen in the air?

705. Thorpe found that the mineral water at Harrogate contained 10·16 grains per gallon of sulphuretted hydrogen. How much iodine solution (containing 0·005 gramme iodine in each cubic centimetre) must be added to a litre of this water, so as to decompose all the sulphuretted hydrogen?

706. A piece of sulphur is heated in contact with 39 c.c. of hydrogen at N.T.P. till combination takes place. Find the volume and weight of the sulphuretted hydrogen produced.

707. How is sulphuretted hydrogen usually prepared? What is it chiefly used for in the laboratory?

708. What impurities are present in sulphuretted hydrogen prepared in the ordinary way? How may it be obtained (*a*) in a purer form, (*b*) perfectly pure?

709. Mention various methods for obtaining sulphur from sulphuretted hydrogen, and state how the gas may be decomposed into hydrogen and sulphur.

710. How may the composition of sulphuretted hydrogen be ascertained?

711. Sulphuretted hydrogen is added to each of the following bodies, state fully what occurs in each case, and give equations for the reactions—(*a*) chlorine, (*b*) sulphurous acid, (*c*) iodine, (*d*) ferric chloride, (*e*) silver nitrate, (*f*) ammonia, (*g*) lime, (*h*) sulphuric acid, (*i*) nitric acid, (*j*) antimony trichloride, (*k*) zinc chloride.

712. A litre of sulphuretted hydrogen is burned in air. Find the volumes of the products at N.T.P., and of the air required for its combustion.

713. What occurs when a mixture of sulphur and paraffin is heated?

714. How may the formation of sulphur dioxide by

the combustion of sulphuretted hydrogen in air be demonstrated?

715. How did Faraday obtain sulphuretted hydrogen in the liquid state? Describe better methods for effecting this result.

716. How is hydrogen persulphide obtained, and what are its properties? What views are held with regard to its composition?

717. Compare the sulphides of hydrogen with the oxides of hydrogen, and point out their analogies.

718. What substance is formed by allowing chlorine to pass over heated sulphur? When the well-cooled product is further treated with chlorine what compound results?

719. How is sulphur tetrachloride obtained? What compounds of sulphur with bromine and iodine have been obtained?

720. When oxygen is passed over heated sulphur, what gaseous compound is formed? If the two gases were passed over finely divided platinum, what compound would result?

721. Sulphur is heated in contact with 173 c.c. of oxygen (at a temperature of 15° C. and under a pressure

of 753 m.m.) till combination takes place. Find the volume of the compound produced, and the weight of sulphur contained in it.

722. How may sulphur dioxide be obtained (*a*) from sulphuric acid, (*b*) from sodium sulphite? How may the gas be liquefied?

723. Give the volume at N.T.P. of each of the gases obtained by heating 489 grammes of charcoal with sulphuric acid.

724. What occurs when sulphuric acid is dropped on red-hot platinum? What quantity of sulphuric acid would yield in this way 1297 c.c. of oxygen gas?

725. Express by equations the reactions which occur when strong sulphuric acid is heated with (*a*) mercury, (*b*) sulphur, (*c*) copper.

726. What is the action of each of the following bodies on sulphur dioxide? (*a*) lead dioxide, (*b*) water, (*c*) hydrogen dioxide, (*d*) nitric acid.

727. Give different methods for preparing sulphur trioxide, also a short account of its properties, and state what occurs when it is passed through a red-hot tube.

728. How is sulphur sesquioxide obtained, and what

occurs when it is heated and when it is added to water?

729. Give the names and formulæ of all oxyacids of sulphur.

730. What acid body is obtained by the action of zinc on sulphurous acid? What name was given to it at first, and what is its more systematic name?

731. By what reactions would you distinguish sulphurous acid from Schützenberger's acid?

732. How would you prepare a solution of sulphurous acid in water? Why can the acid not be obtained except in solution?

733. What occurs when an aqueous solution of sulphurous acid is (*a*) exposed to air, (*b*) added to infusion of rose leaves, (*c*) mixed with chlorine water?

734. How does sulphurous acid act as a bleaching agent? Compare its bleaching action with that of chlorine. Give equations.

735. What is the action of solution of iodine on sulphurous acid in dilute and in strong solutions? Express the reactions by equations.

736. If 432 c.c. of iodine solution (containing 0·005 gramme iodine in each c.c.) were added to a solution

of sulphurous acid (containing a little starch) before a blue colour appeared, how much sulphur dioxide was in solution?

737. Express by equations the reactions which occur when hydrochloric acid is added to (*a*) sodium sulphite, (*b*) sodium thiosulphate.

738. What is the action of sulphur dioxide on iodic acid, and how may the reaction be used as a test for the gas?

739. What is meant by an "antichlor"? Explain the use of sulphur dioxide as an antichlor.

740. What occurs when sodium sulphite is digested with sulphur? Give the formula of the body produced, and show how it is related to sulphite and sulphate of sodium.

741. What reaction occurs when sodium sulphite is treated with zinc and a dilute acid?

742. How is sodium thiosulphate made on the large scale, and what is it used for in photography?

743. Give all the reactions by which you could distinguish a sulphite from a thiosulphate.

744. What occurs when a solution of iodine is added to a solution of sodium thiosulphate? Name all the

28. What are the best tests for nitric acid, and how
y these tests be applied to the detection of nitrates ?

29. Starting with nitric acid, how may each of the
des and acids of nitrogen be obtained? Give equa-
ns.

30. Name all the bodies which can be obtained by
action of nitric acid of different strengths on zinc.
plain the formation of each and give equations.

31. What is the action of strong nitric acid on (*a*)
phur, (*b*) mercury, (*c*) sulphur dioxide, (*e*) tin, (*f*)
sphorus ?

32. How much pure nitric acid is present in 159 tons of
ic acid, 100 grammes of which neutralize 44·3 grammes
e caustic potash?

33. Name four metals which are not acted
ic acid, and state how solutions of eac
ained.

34. What is aqua regia ? Wh
red to prepare it, and what

35. What is the fo
v is it related t
salts obtain

[illegible]

[illegible]

636. Give [illegible] phine, and [illegible] by direct union of [illegible]

637. What [illegible] phosphine is left in [illegible] phur, (c) potassium [illegible]

638. How is [illegible] change in [illegible] through [illegible]

6[illegible]

ta[illegible]

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760. How much sulphuric acid should be theoretically obtained from 197 tons of iron pyrites, if the burnt ore contained 2·74 per cent. of sulphur?

761. What occurs when sulphuric acid vapour is heated?

762. What occurs when sulphuric acid is left exposed to the air?

763. What is the action of sulphuric acid on lead? What is the composition of the precipitate which forms when commercial sulphuric acid is diluted with water?

764. How would you detect the presence of arsenic in sulphuric acid, and how do you account for its presence?

765. How much sulphuric acid is contained in a litre of a liquid, of which 100 c.c. require 1·97 gramme barium chloride for complete precipitation?

766. How much sulphuric acid is required exactly to decompose 2·345 grammes of sodium carbonate?

767. How would you prepare a solution of sulphuric acid, such that each cubic centimetre should contain 0·098 gramme H_2SO_4?

768. What is the action of strong sulphuric acid on each of the following bodies? (*a*) sodium nitrate, (*b*) oxalic acid, (*c*) lead, (*d*) zinc, (*e*) potassium chloride, (*f*) manganese dioxide. Give equations.

769. What is the action of sulphuric acid on organic matter such as sugar?

COMPOUNDS OF SELENIUM.

770. How is seleniuretted hydrogen usually obtaine Compare its properties with those of sulphuret hydrogen.

771. What oxide is formed by burning selenium oxygen? What is the action of water on it?

772. Give the names and formulæ of the oxychlori and chlorides of selenium which have been obtained.

773. Give a short account of the acids of seleniu and point out their analogies with the acids of sulphur.

COMPOUNDS OF TELLURIUM.

774. How is telluretted hydrogen obtained, and what is the weight of a litre of it at N.T.P.?

775. Write the formulæ of all the corresponding compounds of sulphur, selenium, and tellurium which contain (*a*) hydrogen, (*b*) chlorine, (*c*) oxygen, and (*d*) hydrogen and oxygen.

776. How much oxygen at N.T.P. would be taken up in each case by burning 69 grammes of (*a*) sulphur, (*b*) selenium, (*d*) tellurium, in air?

SECTION II.

METALS AND THEIR COMPOUNDS.

SECTION II.—METALS AND THEIR COMPOUNDS.

INTRODUCTORY SUBJECTS.

777. How are the metals distinguished from the non-metals? Name some elements which cannot well be placed in either class.

778. To what substances was the name metalloid originally applied, and how is it now used?

779. How would a chemist proceed to examine a new element so as to decide whether to class it with the metals or the non-metals?

780. What is meant by each of the following terms applied to metals? (*a*) tenacity, (*b*) malleability, (*c*) ductility, (*d*) lustre, (*e*) conductivity for heat and electricity.

781. How does increase of temperature usually affect (*a*) the malleability, (*b*) the tenacity, (*c*) the conductivity of metals?

782. How would you obtain lead, tin, bismuth, silver, and potassium in well-defined crystals?

783. Arrange in order of (*a*) fusibility, (*b*) ductility, (*c*) tenacity, (*d*) specific gravity, (*e*) conductivity, the following list of metals—iron, gold, mercury, silver, potassium, zinc, lead, lithium, platinum, antimony, copper, tin, and bismuth.

784. What property do you regard as most characteristic of the metals?

785. When the terminals from a galvanic battery are placed in an easily decomposed metallic chloride, at which pole should the metal appear? How are the metals and metalloids classified from their electrical relations?

786. Define the terms "specific heat" and "atomic heat." How would you ascertain the specific heat of mercury and of sodium?

787. A kilogramme of mercury at 100° C. was mixed with one of water at 10° C. The temperature of the mixture fell to 12·°98 C. Find the specific heat of the mercury.

788. Describe Bunsen's ice calorimeter.

789. How does the determination of the specific heat

of an element serve to control the determination of combining weight?

790. How may the atomic heat of an element be ascertained from the molecular heat of one of its compounds?

791. What are alloys and amalgams? What is remarkable about the fusing point of alloys?

792. Explain the terms "atomicity of the elements" and "quantivalence of the metals."

793. Arrange the elements in the order of their combining weights from hydrogen to bromine, and point out any coincidences which that arrangement suggests.

794. Give a short account of Mendelejeff's researches on the connection between the atomic weights and the chemical and physical properties of the elements.

795. Point out how Mendelejeff's classification has aided chemical investigations.

796. Give a short history of the various researches on light which led to the introduction of spectrum analysis by Bunsen and Kirchhoff.

797. How has spectrum analysis advanced our know-

ledge (*a*) of the sun and stars, (*b*) of the metals, (*c*) of the distribution of the elements?

798. Describe the construction of a spectroscope, and explain how it is used for the detection of (*a*) metallic salts, (*b*) gases, (*c*) coloured liquids such as blood, solution of permanganates, &c. What are absorption spectra?

MONADS.

LITHIUM.

799. How does lithium occur in nature? From what sources, and how, are the lithium compounds prepared?

800. How is the metal obtained, and what are its properties? Give reasons for classing it with the alkali metals.

801. How much lithium by bulk would weigh the same as 1 c.c. of platinum?

802. By what reactions is lithium distinguished from potassium and sodium? How could small quantities of lithium salts be detected in a mineral water?

SODIUM.

803. Mention the chief natural sources of sodium compounds. How is the metal prepared on the large scale, and what is it chiefly used for?

804. Give a full account of Leblanc's process for the preparation of soda from common salt, and illustrate the changes which occur by equations.

805. What improvements on the original process of Leblanc have been recently introduced?

806. In practice 1,800 lbs. of salt (containing 2·4 per cent. of impurities) are treated with 1,800 lbs. of vitriol having a specific gravity of 1·42 (= 52·8 per cent. H_2SO_4) for the preparation of salt-cake. Find how much hydrochloric acid and sodium sulphate should theoretically be obtained from these quantities of material.

807. For the preparation of black ash, 224 lbs. each of salt-cake and limestone are fused with 140 lbs. coal. What quantities are theoretically required for this weight of salt-cake?

808. What are the chief constituents of commercial salt-cake, black ash soda ash, and caustic soda?

809. How are each of the substances mentioned in the previous question analysed?

810. What is "vat waste," and what useful products may be obtained from it?

811. Describe Mond's process for the recovery of sulphur from vat waste, and state the principles involved in the process.

812. Describe Hargreaves' process for the manufacture of salt-cake without the use of sulphuric acid.

813. How is black ash treated so as to obtain (*a*) soda ash, (*b*) caustic soda, (*c*) soda crystals (crystallized sodium carbonate)?

814. How is sodium bicarbonate prepared on the large scale? Is its reaction alkaline, acid, or neutral? Why is it called an acid salt, and what occurs when it is heated?

815. How would you make a complete quantitative analysis of (*a*) salt-cake, (*b*) soda ash, (*c*) caustic soda?

816. Describe the process called the ammonia-soda process, and give the reactions on which it depends.

817. Describe the various methods in use for obtaining common salt from (*a*) sea-water, (*b*) brine springs, (*c*) salt beds.

818. How is perfectly pure caustic soda obtained? What are the chief impurities in the commercial product?

819. By what reactions are the sodium compounds usually recognised? Name any insoluble sodium salts.

POTASSIUM.

820. What are the chief natural sources of the potassium compounds? Suggest a process for obtaining potash from felspar.

821. Describe the various methods of Davy, Gay Lussac and Thenard, and Matthiessen, for the preparation of potassium, and state how it is now obtained on the large scale.

822. How did Dittmar and Dewar determine the vapour density of potassium, and what was the result?

823. How may caustic potash be obtained perfectly pure?

824. How is potassium chlorate prepared on the large scale?

825. How is the presence of potassium nitrate in the soil in certain parts of India accounted for?

826. Describe the process for the artificial preparation of nitre. By whom and under what circumstances was it introduced?

827. Describe the experiments of Schlœsing and

Müntz and of Warington on nitrification, and state the conditions necessary for the success of the process.

828. What are the constituents of gunpowder, and how is it made?

829. Mention the chief gaseous and solid products obtained by the explosion of gunpowder. How is the formation of each accounted for?

830. Taking the composition of gunpowder as 75 nitre, 10 sulphur, and 15 charcoal in 100 parts, and assuming that all the carbon is converted into carbon dioxide, and all the nitrogen obtained in the free state, find the volume of these gases at N.T.P. which should be evolved by the explosion of one gramme of the powder.

831. Able and Noble found that 1 gramme of gunpowder yielded by explosion in a closed vessel 280 c.c. of gases at N.T.P. What volume would they occupy at 2200° C. which is the temperature at the moment of exploding?

832. A piece of potassium when thrown on water yielded enough potash to neutralize exactly 79 c.c. of a solution of sulphuric acid containing 9·8 grammes H_2SO_4 per litre. Find the weight of the potassium.

833. How are the nitrite and carbonate of potassium obtained, and what are their properties?

834. How could you prepare potassium carbonate from the bicarbonate, and *vice versâ*?

835. What weights of potassium carbonate and of bicarbonate would be required to yield when treated with acid 1 litre of carbon dioxide at N.T.P.?

836. How are the potassium salts distinguished from those of ammonium and sodium?

837. Discuss the reasons for supposing that the salts of ammonia contain a hypothetical metal "ammonium." What is the so-called ammonium amalgam?

838. Compare the salts of potassium with those of ammonium, and point out their analogies.

839. What is meant by dissociation? Describe an experiment which proves the dissociation of ammonium chloride.

840. Describe the preparation of the carbonates and sulphides of ammonium.

RUBIDIUM AND CAESIUM.

841. Give a short account of Bunsen's discovery of rubidium and caesium, and give reasons for classing them with the alkali metals.

842. How is rubidium chloride obtained from lepidolite?

843 How is the metal rubidium prepared, and what are its properties?

844. Give the derivation of the names rubidium and caesium.

845. How may caesium and rubidium salts be separated?

846. What is the formula for caesium alum? How can pure caesium sulphate be obtained from it?

SILVER.

847. How is silver extracted from its ores (*a*) in Mexico, (*b*) in Freiberg?

848. Describe the processes for the extraction of silver known as Ziervogel's, Augustin's, and Von Patera's. Explain the chemical reactions involved in each process.

849. What is the composition of English silver coin? How is the assay of an alloy of silver performed by the dry and wet methods?

850. How is silver extracted by the cupellation process? How is the "spitting" of silver in this process accounted for?

851. What occurs (*a*) when silver is heated to redness in air, (*b*) when steam is passed over melted silver, (*c*) when hydrochloric acid gas is passed over hot finely divided silver, (*d*) when chlorine is passed over heated silver?

852. How are the oxides, chloride and nitrate of silver prepared, and what are their properties?

853. Of what use are the silver salts in photography?

How is a negative taken, and how is a "print" obtained from it? State in each case how the result is rendered permanent.

854. Give a short historical sketch of the discovery of photography, and state the improvements due to Wedgwood, Niépce, Daguerre, Fox Talbot, Herschell, and Archer.

855. How is silver nitrate used in the analysis of chlorides, and how would you determine the amount of silver in a coin?

856. 2·971 grammes of a metallic chloride on precipitation with a silver salt yielded 4·098 grammes silver chloride. Find the per cent. of chlorine in the salt, and its formula.

857. What happens when pure hydrogen is left in contact with solution of silver nitrate?

858. Russell found that 105·3 c.c. of hydrogen at N.T.P. precipitated 1·0089 gramme silver from a solution of silver nitrate. Calculate from this result the combining weight of silver.

THALLIUM.

859. How is thallium found in nature, and from what substance is it most conveniently obtained? Describe the methods of preparation.

860. Discuss the position of thallium among the metals, and point out its analogies to the alkali metals, and to lead.

861. How did Crookes determine the combining weight of thallium?

862. How could you separate thallium from a mixture containing the chlorides of lead, thallium and potassium?

863. Find the percentage of thallium in a sample of thallium chlorate, of which 0·223 gramme yielded 0·3138 gramme double chloride of platinum and thallium. To what formula do these results correspond?

864. Give the formulæ for the oxides, chlorides, and hydrate of thallium, and state how each is obtained. What is the action of the hydrate on solutions of iron and aluminium?

865. How is thallium detected and estimated?

DYADS.

CALCIUM.

866. What is the composition of the following minerals containing calcium? (*a*) aragonite, (*b*) fluorspar, (*c*) gypsum, (*d*) calcite, (*e*) dolomite, (*f*) anhydrite, (*g*) Iceland spar, (*h*) selenite, (*i*) apatite, and (*j*) marble.

867. How is the metal calcium prepared, and what are its properties?

868. How much lime should be obtained by heating to redness 2·726 kilogrammes of calc-spar, and how much calcium hydrate should be obtained on slaking the product?

869. How is lime prepared on the large scale? How are hydraulic mortars obtained?

870. Enumerate the chief uses of lime, and state the causes of the hardening of mortar.

871. Starting with a piece of marble, how would you prepare (*a*) lime-water, (*b*) milk of lime, (*c*) calcium chloride, (*d*) quick-lime?

872. Represent by equations the reactions which occur when chlorine is led into cold and into hot milk of lime.

873. A litre of water at 10° C. when saturated with carbon dioxide, dissolves 0·88 gramme calcium carbonate. What volume of such water contains 100 tons of calcium carbonate?

874. Explain the formation of stalactites, stalagmites, and petrifactions.

875. What is the cause of temporary, and of permanent hardness in water? How may each kind of hardness be removed or modified?

876. How is Clark's soap test applied to determine the hardness of water? How can it be used to ascertain both the temporary and permanent hardness?

877. What is plaster of Paris and how is it made? What loss of weight should one pound of pure selenite suffer when heated to 200° C.?

878. Sea-water contains 1·33 gramme calcium sulphate, and 0·047 gramme calcium carbonate in 1,000 grammes. Find what weight of the water treated with ammonium oxalate should yield 3·24 grammes calcium oxalate.

STRONTIUM.

879. By whom was strontium discovered, and why was the name given to the metal? Who first obtained the metal and in what year?

880. How could you obtain strontium-nitrate (*a*) from strontianite, (*b*) from celestine?

881. Give the formulæ of the hydrates of strontium and state how each is obtained.

882. How could you obtain sulphur from strontium sulphate?

883. A litre of water at the ordinary temperature dissolves 0·145 gramme strontium sulphate. Find how much of this solution would be required exactly to precipitate one gramme of barium chloride.

884. How are strontium salts distinguished from those of calcium?

BARIUM.

885. Name the common minerals which contain barium, and state how the metal is best obtained.

886. What is baryta, and how is it prepared? What is the action of water on it?

887. Describe Pettenkofer's method for determining the amount of carbonic acid in air by means of baryta.

888. What occurs when barium monoxide is heated in a current of air or oxygen? What occurs on heating the product strongly?

889. How are chloride and nitrate of barium prepared on the large scale, and what are their chief uses?

890. How could you obtain oxygen from barium sulphate?

891. How may barium sulphate be distinguished from the sulphates of lead and strontium?

892. What occurs when barium sulphate is fused with sodium carbonate? Represent the reaction by an equation.

893. What substances when heated in a non-luminous flame tinge it green? How are they distinguished?

MAGNESIUM.

894. What is the composition of the following naturally occurring magnesium compounds, and which are used as sources of magnesium salts? (*a*) talc, (*b*) carnallite, (*c*) meerschaum, (*d*) magnesite, (*e*) asbestos, (*f*) serpentine, (*g*) dolomite, (*h*) kieserite, (*i*) spinelle.

895. Describe fully the preparation of magnesium (*a*) on the small scale by Bunsen's method, (*b*) on the large scale by Deville and Caron's process.

896. How is the crude metal purified and made in the form of wire and ribbon? What is magnesium chiefly used for?

897. What occurs when magnesium is (*a*) burned in air, (*b*) placed in boiling water, (*c*) heated in contact with ammonia or nitrogen, (*d*) heated in a covered Hessian crucible in an ordinary coal-fire, (*e*) heated with boron trioxide?

898. What occurs when solution of magnesium chloride is evaporated to dryness? How is anhydrous magnesium chloride obtained?

899. How is magnesium sulphate obtained from kieserite and from dolomite?

900. What is the composition of the precipitate produced by adding a soluble phosphate to a solution of a magnesium salt containing ammonia and ammonium chloride? What occurs on heating this precipitate? Give an equation.

901. How are the following magnesium compounds obtained, and what is the composition of each? (*a*) calcined magnesia, (*b*) fluid magnesia, (*c*) magnesia alba.

902. Give an account of Black's experiments on magnesia by which he clearly proved the nature of the difference between carbonated and caustic alkalies.

ZINC.

903. Name the chief ores of zinc, and describe the processes used for its extraction by the Silesian, Belgian, and English processes.

904. What impurities are usually present in commercial zinc? How may each be detected, and how may zinc be obtained perfectly pure?

905. Under what conditions of temperature is zinc malleable or brittle? How is sheet zinc made?

906. How is the so-called "galvanised iron" made, and what advantages does it possess over sheet iron?

907. What is the action of acids, alkalies, and water on zinc? What is the copper zinc couple, and what is it used for?

908. Give the composition of the common alloys, containing zinc.

909. How is zinc oxide made? Describe the preparation of the chloride and sulphate, and give their properties.

910. How has the vapour density of zinc been determined and with what result?

CADMIUM.

911. How may the presence of cadmium in ores of zinc be ascertained?

912. How is the metal cadmium obtained on the large scale?

913. What occurs when zinc is added to solutions of cadmium salts?

914. How is cadmium hydrate obtained, what is its formula, and how is it distinguished from zinc hydrate?

COPPER.

915. Name the chief ores of copper, and state from which the metal is most commonly obtained.

916. Describe fully the Welsh process for the extraction of copper from its ores. How is copper extracted at Mansfeld in Prussia?

917. Describe the processes for assaying copper ores known as the Cornish method and the wet method.

918. What processes have been proposed for obtaining copper from the burnt pyrites of sulphuric acid works?

919. What is the action on copper of each of the following bodies? (*a*) sulphuric acid, (*b*) ammonia, (*c*) nitric acid, (*d*) chlorine.

920. What happens when steam is passed over copper intensely heated?

921. How is copper hydride obtained, and what is its formulæ? What is the action of hydrochloric acid on it?

922. How are cuprous and cupric oxides prepared? Give two methods for each.

923. Give the formulæ for the chlorides of copper and describe their preparation. What is the action of cuprous chloride on carbon monoxide?

924. How is copper sulphate obtained commercially? What occurs (*a*) when it is heated, (*b*) when ammonia is added to a solution of it?

925. What is the composition of each of the following bodies? (*a*) malachite, (*b*) atacamite, (*c*) verdigris, (*d*) chrysocolla, (*e*) Scheele's green.

926. What happens when potassium iodide is added to a solution of copper sulphate?

MERCURY.

927. How does mercury occur in nature, and how is it extracted by (*a*) the Almaden process, (*b*) the Idrian process, (*c*) the Palatinate process? Describe the methods employed for assaying mercury ores.

928. How is mercury freed from other metals and obtained pure? At what temperatures does it freeze and boil?

929. How did Faraday prove that mercury is volatile at ordinary temperatures?

930. Starting with mercury, how may the oxides and chlorides of mercury be prepared?

931. How may calomel be prepared from corrosive sublimate, and what is the antidote to poisoning with the latter?

TRIADS.

ANTIMONY.

932. How is antimony prepared from the sulphide, and what are the chief uses of the metal?

933. How is amorphous antimony obtained, and what are its properties?

934. Give different methods for the preparation of antimoniuretted hydrogen (stibine).

935. What happens when stibine is passed (*a*) into silver nitrate solution, (*b*) over sulphur exposed to light, (*c*) into solution of potassium permanganate, (*d*) through a red-hot tube?

936. Give an equation to represent the action of stibine on sulphur, and state how the reaction was used to ascertain the composition of the gas.

937. Give all the reactions you know for distinguishing stibine from arsine.

938. How are the trichloride, pentachloride and oxychloride of antimony prepared? What is the action of water on each?

939. Compare the compounds of antimony with those of arsenic and phosphorus, and point out the analogies between them.

940. What is the composition of tartar emetic? How is the salt prepared?

941. How has the combining weight of antimony been determined? What is the result of the most recent determinations?

942. What is the action of strong hydrochloric acid on antimony trisulphide, and of the products on each other? Give equations.

943. What volume of sulphuretted hydrogen at N.T.P. is required to precipitate completely 7·89 grammes of tartar emetic?

BISMUTH.

944. How is bismuth obtained in well-defined crystals, and what is its crystalline form?

945. Describe the liquation process for obtaining bismuth, and also the process by reduction with iron.

946. What are the constituents of "fusible metal"? At what temperature does it melt, and what are its uses?

947. What are the properties of bismuth, and how is a solution of it most easily made?

948. Give equations for the reactions which occur when phosphorus, arsenic, antimony, bismuth, and tin are treated with nitric acid.

949. Suggest methods for preparing a compound of bismuth with hydrogen.

950. Give two methods for obtaining bismuth chloride. What is its formulæ, and what is its action on water?

951. What are the most characteristic tests for bismuth salts? How could you distinguish the oxychlorides of bismuth and antimony?

GOLD.

952. Give a short account of the natural occurrence and distribution of gold.

953. How is the quantity of gold in auriferous minerals, and in gold bullion ascertained?

954. Describe how gold is extracted (*a*) by placer mining, (*b*) by vein mining, (*c*) by hydraulic mining.

955. Give a short account of Plattner's chlorination process for the extraction of gold.

956. How is gold separated from silver and copper by "parting"?

957. How may gold be refined by means of chlorine?

958. How may a solution of gold be obtained? Name any reagents which precipitate metallic gold from the chloride.

959. What are the properties of gold? State the action of acids and alkalies on it, and how the oxides of gold are obtained.

TETRADS.

TIN.

960. From what ore is tin invariably prepared? Describe the various processes employed in its extraction.

961. How is tin-plate made? What is the composition of the following alloys of tin? (*a*) pewter, (*b*) solder, (*c*) gun-metal, (*d*) bronze, (*e*) speculum metal, (*f*) Britannia metal.

962. Express by equations the action of nitric, hydrochloric and sulphuric acids on tin.

963. How are each of the chlorides of tin prepared? Why does stannous chloride solution become turbid after exposure to air, and how may this be prevented?

964. What occurs when zinc is added to an acid solution of stannous chloride? What is the action of stannous chloride on mercuric chloride and on ferric chloride?

965. What is the constitution of stannic and of metastannic acids, and how is sodium stannate prepared?

ALUMINIUM.

966. Name some of the most abundant minerals containing aluminium, and give the composition of cryolite, orthoclase, and wavellite.

967. By whom and when was the metal aluminium first prepared? What are its properties?

968. How is aluminium prepared on the large scale, and what is it chiefly used for?

969. Find the quantity of sodium which is theoretically required to decompose 197 pounds of the double chloride of aluminium and sodium. How much potassium would be required for the same purpose?

970. What is the composition of the ruby, and how may it be prepared artificially?

971. What is the action of the common acids and alkalies on aluminium? Starting with metallic aluminium, how would you prepare potash alum?

972. How are aluminium chloride and the double chloride of aluminium and sodium prepared?

973. How are aluminium sulphate, alum cake, and common alum respectively obtained?

974. What is the constitution of the alums? Give the formulæ for each of the following—ammonia alum, chrome alum, and silver alum.

975. How much ammonia alum contains 156 grammes of aluminium? How much aluminium sulphate and ammonium sulphate must be used to obtain 1,897 grammes of the alum?

976. What is a "mordant"? Explain how alum is used as a mordant.

977. What occurs when aluminium acetate solution is boiled? How is the substance used in calico-printing?

978. Give a short description of the manufacture of glass and of pottery.

MANGANESE.

979. What is pyrolusite, and how may manganese be prepared from it? What is the action of manganese on water?

980. Give a short account of each of the oxides of manganese, and state how they may be obtained from the dioxide.

981. Which oxide of manganese loses, when heated till constant, 3·37 per cent. of oxygen?

982. How much pure manganese dioxide is required when heated in a current of hydrogen to yield 798 grammes of water?

983. Express by equations the action of hydrochloric and sulphuric acids on each of the oxides of manganese.

984. What evidence is there for supposing the existence of a tetrachloride of manganese?

985. How are manganate and permanganate of potassium prepared, and what are their properties?

986. What is the action of each of the following bodies on solution of potassium permanganate? (*a*) hydrogen, (*b*) ammonia, (*c*) stibine, (*d*) ferrous sulphate,

(*e*) oxalic acid, (*f*) sulphuretted hydrogen, (*g*) manganese chloride.

987. How is manganese dioxide recovered, by Weldon's process, from manganese chloride?

988. When the higher oxides of manganese are heated in a current of hydrogen, what body remains, and what are its properties?

989 2·6789 grammes of an oxide of manganese when heated till constant in hydrogen left a residue which weighed 2·4907 grammes. Find the composition of the oxide.

990. Give three distinct methods for ascertaining the quantity of MnO_2 in a sample of commercial manganese dioxide. Describe the advantages of each method.

991. 0·139 gramme of pyrolusite when treated with hydrochloric acid yielded enough chlorine to liberate 0·336 gramme iodine from potassium iodide. Find the percentage of MnO_2 in the pyrolusite.

992. Represent by equations the action of sulphuric acid, and of sulphuric acid in presence of potassium oxalate on manganese dioxide.

993. What happens when (*a*) manganese chloride and (*b*) manganese dioxide are strongly heated in air?

994. How is potassium manganese alum prepared? Give the proportions of each constituent required.

995. In an analysis of pyrolusite by Fresenius' method, the following results were obtained:—

2·2711 grammes of the oxide yielded 1·7091 gramme carbon dioxide. Find the percentage of MnO_2 in the oxide.

996. 0·7804 gramme of a hydrated oxide of manganese left, when heated in hydrogen, 0·5674 gramme residue. Find the percentage of manganese and the formula of the hydrate.

997. What weight of manganese dioxide when heated should yield 2·76 litres of oxygen at 14° C., and 754 m.m. pressure?

CHROMIUM.

998. What is chrome iron ore, and how is it treated so as to prepare potassium chromate?

999. Describe the preparation of the chlorides and oxides of chromium, and state from which the metal may be most easily obtained.

1000. How may potassium bichromate be converted into the chromate and *vice versâ?*

1001. Give equations for the reactions which occur when each of the following bodies is added to solution of potassium bichromate—(*a*) silver nitrate, (*b*) sulphuric acid, (*c*) potash, (*d*) sulphuretted hydrogen, (*e*) sulphur dioxide.

1002. What is the formula for chrome alum? Give two distinct methods for preparing it.

1003. What occurs when the bichromate of potassium and the bichromate of ammonium are separately heated?

1004. What is chlorochromic acid, and how is it prepared? What is its action on water? Express the reactions by equations.

1005. Compare the analogous compounds of chromium and sulphur, and name any chromium compounds which are isomorphous with the corresponding sulphur ones.

1006. What happens when a solution of chromic acid is treated with zinc?

1007. How much oxygen by weight and volume should be evolved by heating 2·98 grammes of potassium bichromate with sulphuric acid, and how much chlorine should be evolved on treating the same quantity with hydrochloric acid?

1008. What is the composition of the crystalline substance formed by treating potassium bichromate with strong hydrochloric acid?

1009. What are the most characteristic tests for the compounds of chromium?

IRON.

1010. Write a list of the most abundant compounds of iron found naturally, and state which are used as sources of the metal.

1011. In what bodies is iron found native? How could you ascertain whether a body contained native or combined iron?

1012. How is chemically pure iron obtained, and what are its properties?

1013. Describe processes for the assay of iron ores: (*a*) by the dry method, (*b*) by means of potassium permanganate.

1014. State briefly how the complete quantitative analysis of an iron ore is made, indicating particularly how the quantities of sulphur, manganese, phosphorus, silica, and iron are ascertained.

1015. Describe how malleable iron is obtained by each of the following processes—(*a*) by the Catalan forge, (*b*) by Siemens' process.

1016. How is cast-iron made? Sketch an ordinary blast-furnace, and explain fully how it is used.

1017. Explain the theory of the iron blast-furnace, and illustrate by equations the most important reactions which occur in the manufacture of cast-iron.

1018. What is the effect of the hot and of the cold blast on the quality of the cast-iron produced in the blast-furnace?

1019. What is the difference in composition between grey and white cast-iron? What is the action of acids on each kind?

1020. What is "spiegeleisen"? How is it made, and what is it chiefly used for?

1021. How is cast-iron treated so as to obtain wrought-iron? How do they differ in composition?

1022. What impurities render iron "red-short" and "cold short"?

1023. How is steel made: (*a*) by the cementation process, (*b*) by Bessemer's process? Sketch the furnaces required for each method.

1024. Describe processes for the analysis of cast-iron, wrought-iron, and steel. Describe also Eggertz's process for the determination of carbon in iron and steel.

1025. Give a full account of the properties of iron. What is iron rust, and how is it produced?

1026. What is meant by the *passive* condition of iron?

1027. What is the action of dilute sulphuric acid on iron? What is the cause of the disagreeable odour produced when iron is dissolved in acids?

1028. Starting with ferrous sulphate, how could you obtain (*a*) metallic iron, (*b*) ferrous oxide, (*c*) iron sesquioxide, (*d*) magnetic iron oxide?

1029. How are ferrous and ferric chlorides and sulphates prepared, and by what reactions are ferrous distinguished from ferric compounds?

1030. How is ferric oxide used in the purification of coal-gas? Explain the reaction and state its advantages over other methods.

1031. State the reactions (if any) which occur when the following reagents are added respectively to ferrous and ferric chlorides—(*a*) hydrated ferrous oxide, (*b*) barium carbonate, (*c*) sodium carbonate, (*d*) potassium iodide, (*e*) sulphuretted hydrogen. Give equations.

1032. Find the formulæ of an iron salt which contains in 100 parts 48 oxygen, 24 sulphur, and 28 iron.

1033. The crystallised double sulphate of iron and ammonia contains one-seventh of its weight of iron: find its formulæ.

1034. What volume of hydrochloric acid gas at N.T.P. is required to convert 89 grammes of pure iron into ferrous chloride, and what volume of chlorine at N.T.P. would convert the latter into ferric chloride?

1035. How is iron alum made? Calculate its percentage composition.

COBALT.

1036. How does cobalt occur in nature? How is the metal prepared, and what are its properties?

1037. What is the colour when anhydrous of (*a*) cobalt chloride, (*b*) cobalt iodide? What changes occur on the addition of water to each?

1038. Give a short account of the ammonio-cobalt bases.

1039. What is the action on cobalt chloride: (*a*) of potassium nitrite, (*b*) of potassium cyanide?

1040. By what reactions is cobalt usually recognised? How is it distinguished from nickel?

NICKEL.

1041. Give a short account of the metallurgy of nickel. What is its chief use in the arts?

1042. Describe a chemical process for preparing nickel perfectly free from cobalt.

1043. What is the composition of German silver?

1044. Compare the properties of nickel and cobalt, and point out the chief differences between them.

1045. It has been suggested that nickel and cobalt are really different forms of the same element. Give reasons for and against this hypothesis.

1046. How may the native sulphides of nickel, cobalt and iron be distinguished from each other?

1047. How is nickel sulphate prepared, and how much of the metal would be required to prepare 798 grammes of the crystallised salt?

PLATINUM.

1048. How does platinum occur in nature, and how is the metal prepared (*a*) by Wollaston's process, (*b*) by the process of Deville and Debray?

1049. Describe the apparatus of Deville and Debray for fusing platinum.

1050. Why are platinum vessels frequently employed by chemists? Name substances which attack platinum.

1051. What are platinum black and spongy platinum? How are they each prepared, and how do they differ from ordinary platinum?

1052. How is platinum tetrachloride prepared, and how may the metal be obtained from it?

1053. Express by equations the action of ammonium chloride on platinum chloride, and of heat on the product.

1054. What is the action (if any) of each of the following bodies when heated with platinum? (*a*) potash, (*b*) silica, (*c*) nitric acid, (*d*) carbon, (*e*) lead, (*f*) sodium carbonate, (*g*) phosphorus, (*h*) chlorine, (*i*) sulphur, (*j*) potassium bisulphate.

LEAD.

1055. What is the composition of the following lead compounds? (*a*) massicot, (*b*) galena, (*c*) litharge, (*d*) cerussite, (*e*) red lead, (*f*) pyromorphite, (*g*) anglesite.

1056. Describe methods for the assay of lead ores, and also for estimating the quantity of silver in argentiferous galena.

1057. How does lead sulphide itself serve for the reduction of the ore, without the addition of reducing agents? Give equations.

1058. Describe the processes for lead-smelting in (*a*) reverberatory furnaces, (*b*) in blast-furnaces, (*c*) in shallow hearths.

1059. What is "lead fume," and what arrangements are made to collect it?

1060. Describe fully Pattinson's process for the desilverisation of lead; also the subsequent process of cupellation to obtain the silver.

1061. How are lead pipes and sheet-lead made?

1062. What is the action of water on lead? Whether does rain, river, or distilled water act most on lead, and what is the reason?

1063. How may lead be obtained chemically pure? Describe methods for obtaining metallic lead in crystals.

1064. What is the action of each of the common acids on lead? Describe the nitrate, chloride, and sulphate of lead.

1065. Describe the oxides of lead, and give methods for their preparation.

1066. How is lead tetrachloride prepared, and what occurs when it is added to water?

1067. Describe the manufacture of acetate of lead and of white-lead. What is the composition of white-lead?

1068. What is the action of nitric acid on red-lead and on galena?

PENTAD.

VANADIUM.

1069. Give a short account of the occurrence of vanadium in nature, and state how the metal is obtained.

1070. How was the combining weight of vanadium ascertained by Roscoe? How did his results differ from those of Berzelius?

1071. Write the formulæ of the oxides, oxychlorides and chlorides, of vanadium (*a*) as given by Berzelius, (*b*) as given by Roscoe.

1072. How is vanadium pentoxide obtained, and what are its properties? What occurs when its solution in sulphuric acid is treated with zinc?

1073. Find the combining weight of vanadium from the following results: (*a*) 6·139 grammes vanadium pentoxide when heated in hydrogen yielded 5·0639 grammes trioxide, (*b*) vanadyl trichloride contains 61·276 per cent. of chlorine.

1074. Compare the compounds of vanadium with those of phosphorus, and point out their analogies.

HEXADS.

MOLYBDENUM, ETC.

1075. What compound of molybdenum results from heating the sulphide in a current of air, and what is the action of ammonia on it?

1076. What is the action of ammonium molybdate on solutions of phosphates? Mention other substances precipitated by the same salt.

1077. How is tungstic acid obtained from sodium tungstate, and how is this salt prepared?

1078. How is tungsten hexachloride prepared? Give the formulæ of all the compounds of tungsten with chlorine, and with chlorine and oxygen.

1079. Name the chief minerals in which molybdenum, tungsten, and uranium occur.

1080. Point out analogies existing between molybdenum, tungsten, and uranium, and also between the last element and vanadium.

1081. Give reactions for distinguishing all the metals mentioned in the previous question.

SECTION III.

ORGANIC COMPOUNDS.

SECTION III.—ORGANIC COMPOUNDS.

INTRODUCTORY SUBJECTS.

1082. How are organic distinguished from inorganic bodies? Give the various definitions of organic chemistry which have been proposed.

1083. Name the elements most commonly found in organic bodies. Which element is present in all organic bodies?

1084. The compounds of carbon are more numerous than those of all the other elements. How do you account for this?

1085. Explain the terms *substitution*, *saturated*, *non-saturated*, *organic radical*, *homologue*, and *hydrocarbon*. Illustrate your meaning by examples.

1086. Give examples of organic and inorganic compound radicals. Give an example of an inorganic homologous series.

1087. How would you examine a substance so as to ascertain whether it is organic or inorganic?

1088. How could you detect the presence of carbon, hydrogen, and oxygen in sugar?

1089. How are chlorine, iodine, sulphur, and nitrogen detected in organic bodies?

1090. Describe fully the process employed for the quantitive analysis of an organic body containing carbon, hydrogen, and oxygen. Sketch the apparatus.

1091. Give two methods for determining the amount of nitrogen present in an organic body.

1092. How is the quantity (*a*) of chlorine, (*b*) of sulphur determined in an organic compound?

1093. Describe Frankland's process for the determination of boron in organic bodies.

1094. How much carbon is contained in each of the following weights of carbon dioxide: (*a*) 1·2769 gramme, (*b*) 0·8793 gramme, (*c*) 0·9876 gramme? How much hydrogen is contained in each of the following weights of water: (*a*) 2·7637 grammes, (*b*) 0·2987 gramme, (*c*) 0·7896 gramme?

1095. If 4·3679 grammes of alcohol (C_2H_6O) were completely burned, what weight of carbon dioxide and of water should be produced?

1096. Calculate the percentage composition and formulæ of the organic compounds which yielded the following analytical results:—

(*a*). Substance taken . . . = 0·757 gramme.
Carbon dioxide obtained = 0·889 ,,
Water obtained . . . = 0·267 ,,
(*b*). Substance taken . . . = 0·3989 ,,
Carbon dioxide obtained = 0·7978 ,,
Water obtained . . . = 0·3329 ,,
(*c*). Substance taken . . . = 0·9002 ,,
Carbon dioxide obtained = 1·7217 ,,
Water obtained . . . = 1·0564 ,,
(*d*). Substance taken . . . = 0·3665 ,,
Carbon dioxide obtained = 0·7331 ,,
Water obtained . . . = 0·1521 ,,
(*e*). Substance taken . . . = 0·4639 ,,
Carbon dioxide obtained = 0·6377 ,,
Water obtained . . . = 0·5217 ,,

1097. 1·2435 gramme of an organic body having the general formula C_nH_{2n} is submitted to analysis. Find the weights of carbon dioxide and water which should be obtained.

1098. Find the percentage composition and formula of a substance from the following analytical results :—

(*a*). Substance taken . . . = 0·2491 gramme.
Carbon dioxide obtained = 0·1829 „
Water obtained . . . . = 0·1492 „ also

(*b*). 0·2381 gramme of the substance yielded 0·4276 gramme ammonium chloride.

1099. A substance containing carbon, hydrogen and nitrogen, gave the following analytical results :—

(*a*). Substance taken . . . = 0·4124 gramme.
Carbon dioxide obtained = 0·9885 „
Water obtained . . . = 0·3491 „ also

(*b*). 0·1123 gramme of the substance yielded 0·8021 gramme double chloride of platinum and ammonium. Find the percentage composition and formula of the substance.

1100. 0·2379 gramme of strychnine ($C_{21}H_{22}N_2O_2$) is analysed. Find the weights of carbon dioxide and water which should be obtained, and the volume of nitrogen measured at 10° C. and 757 m.m. pressure.

1101. In the analysis of a silver salt the following results were obtained by Frankland :—

(*a*). Substance taken . . . = 0·4108 gramme.
Carbon dioxide obtained = 0·2133 „
Water obtained . . . = 0·0653 „ also
(*b*). 0·36 gramme yielded on ignition 0·232 gramme silver. Find the percentage composition and formula of the salt.

1102. What weight of silver chloride should be obtained in the analysis of 0·7899 gramme of chloral?

1103. Why is it important to ascertain if possible the vapour density of an organic body?

1104. Describe the methods for ascertaining vapour density introduced by (*a*) Dumas, (*b*) Gay-Lussac, (*c*) Hofmann.

1105. Find the vapour density of an organic compound from the following data :—

	Grammes.
Weight of globe filled with dry air	= 44·7832
„ „ vapour at 115° C.	= 45·1848

Capacity of globe = 189·6 c.c.
Temperature = 12·8° C. Barometer = 751 m.m.

1106. In a determination of the vapour density of boric ethide, Frankland obtained the following results :—

Weight of boric ethide . . = 0·2839 gramme.
Volume of vapour . . . = 96·68 c.c.
Temperature of oil bath . = 149° C.
Barometer . . . . = 760·5 m.m.
Height of mercury inside the tube above that outside . = 1·5 m.m.
Height of column of oil . = 328·0 m.m.

Calculate the density of the vapour.

1107. Describe fully all the methods used for ascertaining the molecular formulæ of organic bodies.

1108. By whom and when was the synthesis of an organic compound first made? Describe fully the method employed.

1109. Give a historical sketch of the introduction of synthesis in organic chemistry.

1110. How may alcohol be built up from inorganic materials?

1111. What are empirical, rational, constitutional, and graphic formulæ? Give examples.

1112. Explain the terms isomerism, metamerism, and nerism, and illustrate your meaning by examples.

1113. Explain the use in organic chemistry of the process called fractional distillation.

1114. Give examples of positive and negative organic and inorganic radicals.

1115. Give constitutional and graphic formulæ for the following organic bodies: (*a*) alcohol, (*b*) marsh gas, (*c*) hydrocyanic acid, (*d*) ether, (*e*) oxalic acid, (*f*) aldehyde, (*g*) acetic ether, (*h*) formic acid, (*i*) urea, (*j*) succinic acid, (*k*) acetic acid, (*l*) benzol, (*m*) benzoic acid.

CYANOGEN AND ITS COMPOUNDS.

1116. What occurs when nitrogen is passed over a strongly heated mixture of charcoal and potassium carbonate? Give an equation.

1117. How is cyanogen gas prepared, and how may it be liquefied? What is its action on potassium?

1118. Starting with cyanogen how may oxalic acid be obtained, and *vice versâ*. Show by formulæ how the two substances are related to each other.

1119. What products are obtained when cyanogen gas burns in air? Give the volumes of each obtained by burning 15 litres of the gas.

1120. Give the weight and volume of cyanogen which should be obtained by decomposing 79 grammes ammonium oxalate with phosphoric anhydride.

1121. What is paracyanogen, and how is it obtained?

1122. What organic compound is formed when sulphuretted hydrogen acts on mercuric cyanide? Give other methods for preparing the same substance.

1123. What is the action of strong and of dilute sulphuric acid on potassium ferrocyanide? Give equations for each reaction.

1124. How would you act on chloroform so as to obtain hydrocyanic acid?

1125. What changes occur when an aqueous solution of hydrocyanic acid is left standing for some time?

1126. How is potassium cyanide made (*a*) from hydrocyanic acid, (*b*) on the large scale? What occurs when it is heated in contact with air?

1127. How is hydrocyanic acid detected in cases of poisoning? How may it be detected in a compound nsoluble in water and not decomposed by acids?

1128. Give different methods for the preparation of potassium ferro- and ferricyanide.

1129. How could you obtain from potassium ferrocyanide (*a*) potassium cyanide, (*b*) hydroferrocyanic acid, (*c*) Prussian blue?

1130. What is Turnbull's blue, and how is it made?

1131. Give a short account of the nitroprussides and sulphocyanides.

METHYL COMPOUNDS.

1132. How does marsh-gas occur in nature? By what other names is the substance known? Give four distinct methods for its preparation.

1133. What are the products of the action of chlorine on marsh-gas?

1134. Nine litres of marsh-gas are mixed with nine of chlorine and exposed to light. Give the volumes and weights of the products.

1135. What weight of sodium acetate when heated with caustic soda is needed to yield 275 c.c. of marsh-gas at N.T.P.?

1136. One hundred and eighty-nine c.c. of marsh-gas are completely burned in air. Find the volume of air required and of the products of combustion at N.T.P.

1137. What volume of oxygen must be exploded with 150 c.c. of marsh-gas so as to ensure complete combustion?

1138. What volume of marsh-gas at N.T.P. when passed over heated copper oxide should yield 10 grammes of carbon dioxide?

1139. Give two methods for the preparation of methyl chloride. What is the action of potash on it?

1140. How is chloroform prepared on the large scale? What is the action of nascent hydrogen, and of chlorine on it?

1141. What products are obtained by the destructive distillation of wood, and how is the wood spirit separated from them, and obtained pure?

1142. How is methyl alcohol obtained from (*a*) methyl chloride, (*b*) gaultheria oil? What is the action of potassium on methyl alcohol?

1143. What volume of oxygen is required for the complete combustion of 7 grammes of methyl alcohol?

1144. What two compounds have the empirical formula C_2H_8N? How is each prepared, and what is the constitutional formula for each? From which, and how, could an ethyl compound be obtained?

ETHYL COMPOUNDS.

1145. Give several reactions for preparing ethyl hydride. How has it been proved identical with dimethyl?

1146. What is the action of chlorine on ethyl hydride?

1147. How is ethyl chloride prepared (*a*) by Grove's method, (*b*) by other methods? What is the action of potash on it?

1148. How is ethyl iodide prepared? What weight of it contains 7·89 grammes of iodine?

1149. How is ethyl alcohol obtained from grape sugar? What other products are simultaneously produced?

1150. What is *absolute* alcohol, and how is it prepared?

1151. How is the amount of alcohol in a mixture of alcohol and water accurately ascertained?

1152. What is the action on alcohol of each of the following bodies? (*a*) sodium, (*b*) chlorine, (*c*) sulphuric acid, (*d*) a mixture of sulphuric acid and potassium bichromate. Give equations for the reactions.

1153. Give the formulæ of several analogous ethyl and potassium compounds.

1154. What occurs when alcohol vapour is passed through a red-hot tube?

1155. How did Berthelot obtain alcohol from inorganic materials? Give other methods.

1156. Seventeen grammes of alcohol are burned completely. Find the volume of carbon dioxide obtained at N.T.P., and also the weight of water produced.

1157. Find the volume of air at N.T.P. required for the complete combustion of 19 c.c. of absolute alcohol at 0° C. (S. G. at 0° C. = 0·80625). Find also the volumes of the gaseous products.

1158. By the action of potassium on alcohol 1987 c.c. of hydrogen at N.T.P. were obtained. Find the weight of alcohol decomposed and of potassium used.

1159. What is the composition of the substance called propiontrile? How is it prepared, and how would you prepare the body with which it is isomeric?

1160. What is mercaptan, and how is it prepared?

ETHYLENE.

1161. Give several methods for the preparation of ethylene. Represent the reactions by equations.

1162. What is the volume at N.T.P. of 7·89 grammes of ethylene, and what volume of oxygen is required to burn it?

1163. Starting with carbon and hydrogen how may ethylene be prepared?

1164. What occurs when a mixture of ethylene with twice its volume of chlorine is kindled?

1165. How may ethylene be made to combine with chlorine? Give the properties of the compound produced, and sketch the apparatus you would employ to prepare it.

1166. Explain the difference in constitution between ethylene and its isomer ethylidene.

1167. What is glycol? State fully how it is prepared, and what occurs when it is oxidized. Give equations.

1168. What is the action (*a*) of potassium, (*b*) of phosphorus pentachloride, (*c*) of hydrochloric acid, on glycol?

ACETYLENE.

1169. What occurs when electric sparks are passed through coal-gas? How may the body produced be collected?

1170. How may acetylene be obtained from (*a*) chloroform, (*b*) methyl chloride, (*c*) coal-gas, (*d*) marsh-gas?

1171. What is the composition of copper acetylide, and how may pure acetylene be obtained from it?

1172. What is the action on acetylene of (*a*) bromine, (*b*) nascent hydrogen, (*c*) sulphuric acid, (*d*) heated potassium?

GLYCERINE.

1173. Explain the terms mono- di- and trihydric alcohols, and give examples of each.

1174. How is glycerine prepared on the large scale from fats? How is it purified?

1175. How could you obtain glycerine from the hydrocarbon C_3H_8?

1176. What is the action on glycerine of (*a*) hydrochloric acid, (*b*) phosphorus pentachloride, (*d*) hydriodic acid?

1177. How is glycerine related to (*a*) propyl glycol, (*b*) isopropylic alcohol, (*c*) acrolein and acrylic acid?

ETHERS.

1178. Define the terms ethers and haloid ethers, and give examples of each derived from mono- di- and trihydric alcohols respectively.

1179. Describe fully the so-called *continuous* process for preparing ether, and give equations for the reactions. How is ether purified?

1180. How may ether be prepared from sodium ethylate? What are *mixed* ethers, and how are they prepared?

1181. How would you separate and detect each constituent in a mixture of alcohol, ether, and water?

1182. What occurs when sodium is dropped into (*a*) pure ether, (*b*) ether containing alcohol?

1183. What volume of oxygen is required for the complete combustion of three volumes of ether vapour? Ether vapour is mixed with fifty times its volume of air and exploded, what is the composition of the residual gases

1184. What volume of ether vapour weighs the same as (*a*) 1 litre of air, (*b*) 2 litres of chlorine, (*c*) 7 litres of carbon dioxide?

1185. How is methylic ether prepared? Compare its chemical and physical properties with those of ethylic ether.

1186. What is acetic ether? Give its formula and describe its preparation.

ALDEHYDES.

1187. How are the aldehydes related to the alcohols and the acids? Give general methods for their preparation. What is the derivation of the name aldehyde?

1188. What is the difference between an aldehyde and a ketone? What is the action of nascent hydrogen on each?

1189. What occurs when a mixture of acetate and formate of potassium is distilled? How does this reaction serve for preparing the homologues of the fatty acids? Give an example and equations for all the reactions.

1190. How is ethyl aldehyde obtained pure? What is the action of ammonia and of alkaline bisulphites on aldehyde?

1191. What is the action of aldehyde on silver oxide? Give an equation.

1192. What is the percentage composition of aldehyde? Name other bodies which have the same empirical formula.

1193. What is chloral? How is it prepared, and how is it related to aldehyde?

MONOBASIC ACIDS.

1194. How does formic acid occur in nature? How may it be produced from inorganic materials? Give two methods.

1195. How is formic acid prepared in quantity and obtained anhydrous?

1196. What occurs (*a*) when sodium formate is heated, (*b*) when a formate is heated with sulphuric acid, (*c*) when formic acid is heated with mercuric oxide, (*d*) when chlorine acts on formic acid, (*e*) when calcium formate is distilled? Give equations for each reaction.

1197. How would you prepare ammonium formate? What occurs when it is heated?

1198. What occurs when potassium hydrate acts on chloroform? Give an equation.

1199. How are hydrocyanic and formic acids related to each other?

1200. How is pyroligneous acid prepared and purified? By what other names is the substance known?

1201. How may acetic acid be obtained from ethyl alcohol? Give other ways for preparing the acid.

1202. Give different methods for preparing vinegar.

1203. What weight of acetic acid would be required to neutralize exactly 7·892 grammes of potassium carbonate?

1204. How is potassium biacetate prepared, and what occurs when it is heated? Give an example of a similar reaction with an inorganic salt.

1205. What is the action of chlorine and of phosphorus trichloride on acetic acid? Give equations.

1206. Give the formulæ of the following bodies: (*a*) silver acetate, (*b*) ethyl acetate, (*c*) potassium mono-chloracetate, (*d*) lead acetate, (*e*) acetyl chloride, (*f*) acetic anhydride, (*g*) acetamide.

1207. You are provided with bromine, acetic acid, sulphuric acid, and potassium cyanide, how would you prepare cyanacetic acid? Give its formula, and state how a dibasic organic acid may be obtained from it.

1208. How may propionic acid be prepared starting with acetic acid?

1209. How is lactic acid related to (*a*) propionic acid, (*b*) malonic acid, (*c*) glycollic acid?

1210. Give a short account of the isomers of lactic acid, and explain their constitution by graphic formulæ.

1211. Give several methods for preparing lactic acid, and state which method you would adopt for obtaining large quantities of it.

1212. How is benzoic acid prepared? In what respects do its reactions and preparation resemble those of acetic acid?

1213. What occurs when benzoic acid is heated with lime? Give an equation.

1214. What is naphthalene, and how may benzoic acid be obtained from it?

1215. By what reactions are formic, acetic, lactic, and benzoic acids recognised?

DIBASIC ACIDS.

1216. Write the formulæ of oxalic acid and its homologues up to adipic acid.

1217. How may oxalic acid be obtained starting with cyanogen and *vice versâ?* How may it be obtained starting with carbon dioxide?

1218. Give reactions (other than those referred to above) for preparing oxalic acid, and give a full account of the method adopted on the large scale.

1219. What is the action on oxalic acid of (*a*) heat, (*b*) potassium permanganate, (*c*) sulphuric acid, (*d*) potassium hydrate? Give equations.

1220. One hundred cubic centimetres of a solution of potassium permanganate are required to saturate a solution of 0·0396 gramme iron. How much of this solution is needed to decompose completely 0·873 gramme crystallized oxalic acid?

1221. How much carbon dioxide by volume and weight should be given off by treating 6·789 grammes oxalic acid with potassium permanganate?

1222. State fully what occurs when a solution of potassium permanganate is added to one of oxalic acid alone, and in presence of sulphuric acid.

1223. How much carbon dioxide and monoxide can be obtained from the oxalic acid required to neutralize 19 grammes of caustic soda?

1224. How many series of salts does oxalic acid form? Give examples of each with formulæ.

1225. Give the formula for each of the following bodies and explain how they are related to oxalic acid: (*a*) oxamide, (*b*) oxamic acid, (*c*) glyoxal, (*d*) glyoxylic acid, (*e*) glycollic acid.

1226. How may succinic acid be prepared (*a*) syntheti cally, (*b*) from malic acid?

1227. How may succinic acid be obtained starting with acetic acid and *vice versâ?*

1228. What is the action of hydriodic acid on tartaric acid?

1229. By what reaction can it be proved that succinic acid contains ethylene, and how may ethylene be obtained from it?

1230. How is tartaric acid prepared, and what is the action on it of (*a*) oxidizing agents, (*b*) caustic potash?

1231. What is the formula of tartar emetic? What percentage of carbon does it contain?

1232. Describe the isomeric modifications of tartaric acid.

TRIBASIC ACIDS.

1233. Give a short account of the natural occurrence of citric acid, and describe how the acid is manufactured.

1234. What different products are obtained by heating citric acid?

1235. What is tricarballylic acid, and how is it related to citric acid?

1236. If 0·276 gramme of citric acid were used in an organic analysis, what weight of carbon dioxide and of water should be obtained?

1237. What is the action of chlorine on citric acid?

1238. By what reactions is citric acid recognised and distinguished from tartaric acid?

BENZOL AND ITS DERIVATIVES.

1239. How has benzol been prepared synthetically?

1240. How is benzol obtained from coal-tar? How is it purified?

1241. 7·892 grammes of benzoic acid are heated with excess of lime. What reaction occurs, and how much of the product is obtained?

1242. What products are obtained by passing alcohol vapour through a red-hot tube?

1243. How would you ascertain the presence of benzol vapour in coal-gas?

1244. Draw the graphic formula of benzol.

1245. What is the action on benzol of (*a*) sulphuric acid, (*b*) nitric acid, (*c*) bromine?

1246. What is aniline? How is it prepared and purified? What is the action of hydrochloric acid on aniline?

1247. What is toluidine, and how is it related to aniline?

1248. What is oil of bitter almonds? To what class of bodies does it belong?

1249. Give a short account of the preparation of a few of the most important coal-tar colours.

AMINES AND AMIDES.

1250. How are amines distinguished from amides?

1251. Describe the preparation of ethylamine, diethylamine, and triethylamine.

1252. Point out the resemblances between ammonia and the amines.

1253. What is the action of ammonia on ethyl iodide and of potash on the product? Give equations.

1254. What is the action of nitrous acid on the amines? Give an example.

1255. To what class of organic bodies does urea belong? Give reasons for placing it in this class.

1256. How much urea when treated with nitrous acid should evolve 179 c.c. of nitrogen at N.T.P.?

1257. Give the formula for acetamide. Describe its preparation and reactions.

APPENDIX A.

TABLE OF THE ELEMENTS WITH THEIR SYMBOLS AND COMBINING WEIGHTS.

Element.	Symbol.	Combining Weight.
Aluminium	Al	27·3
Antimony	Sb	120
Arsenic	As	75·2
Barium	Ba	137
Beryllium	Be	9·3
Bismuth	Bi	210
Boron	B	11
Bromine	Br	80
Cadmium	Cd	112
Cæsium	Cs	133
Calcium	Ca	40
Carbon	C	12
Cerium	Ce	92·2

Element.	Symbol.	Combining Weight.
Chlorine	Cl	35·5
Chromium	Cr	52
Cobalt	Co	58·7
Copper	Cu	63·5
Didymium	D	95
Erbium	E	112·6
Fluorine	F	19
Gallium	Ga	69·8
Gold	Au	197
Hydrogen	H	1
Indium	In	113·4
Iodine	I	127
Iridium	Ir	198
Iron	Fe	56
Lanthanum	La	92·9
Lead	Pb	207
Lithium	Li	7
Magnesium	Mg	24
Manganese	Mn	55
Mercury	Hg	200
Molybdenum	Mo	96
Nickel	Ni	58·7

Element.	Symbol.	Combining Weight.
Niobium	Nb	94
Nitrogen	N	14
Osmium	Os	199·1
Oxygen	O	16
Palladium	Pd	106·6
Phosphorus	P	31
Platinum	Pt	197·5
Potassium	K	39·1
Rhodium	Rh	104·2
Rubidium	Rb	85·4
Ruthenium	Ru	104·4
Selenium	Se	79·5
Silver	Ag	108
Silicon	Si	28
Sodium	Na	23
Strontium	Sr	87·5
Sulphur	S	32
Tantalum	Ta	182·3
Tellurium	Te	128
Thallium	Tl	203·5
Thorium	Th	115·7
Tin	Sn	118

Element.	Symbol.	Combining Weight.
Titanium	Ti	50
Tungsten	W	184
Uranium	U	120
Vanadium	V	51·3
Yttrium	Y	61·6
Zinc	Zn	65·2
Zirconium	Zr	89.6

APPENDIX B.

METRIC SYSTEM OF WEIGHTS AND MEASURES.

1 metre = 39·37 inches
10 metres = 1 decametre
100 metres = 1 hectometre
1000 metres = 1 kilometre
$\frac{1}{10}$ metre = 1 decimetre
$\frac{1}{100}$ metre = 1 centimetre
$\frac{1}{1000}$ metre = 1 millimetre

1 gramme = 15·43 grains
10 grammes = 1 decagramme
100 grammes = 1 hectogramme
1000 grammes = 1 kilogramme
$\frac{1}{10}$ gramme = 1 decigramme
$\frac{1}{100}$ gramme = 1 centigramme
$\frac{1}{1000}$ gramme = 1 milligramme

1 litre = 61·02 cubic inches, and contains 1000 cubic centimetres.
1 litre of water at 4° C. weighs 1000 grammes.
1 gallon = 4·5434 litres.

APPENDIX C.

SPECIFIC GRAVITY OF GASES AND VAPOURS.

Elementary Gases or Vapours.	1 litre of hydrogen at 0° C. and under a pressure of 760 m.m. of mercury, weighs 0·0896 gramme = 1 crith.				
	1 litre of oxygen (c.w.=16)	under the same circums.	weighs	16 criths=0·0896 × 16=1·4336	grammes
	1 litre of nitrogen (c.w. = 14)	,,	,,	14 criths = 0·0896 × 14 = 1·2544	,,
	1 litre of iodine vapour (c.w.= 127)	,,	,,	127 criths = 0·0896 × 127 = 11·3792	,,
Compound Gases.	1 litre of water vapour (m.w.= 18)	,,	,,	$\frac{18}{2}$= 9 criths = 0·0896 × 9 = 0·0864	,,
	1 litre of carbonic anhydride (m.w.= 44)	,,	,,	$\frac{44}{2}$= 22 criths = 0·0896 × 22 = 1·9712	,,
	1 litre of ammonia gas (m.w.= 17)	,,	,,	$\frac{17}{2}$= 8·5 criths = 0·0896 × 8·5 = 0·7616	,,
	1 litre of hydrochloric acid gas (m.w.= 36·5)	,,	,,	$\frac{36.5}{2}$=18·25 criths=0·0896 × 18·25 =1·6352	,,
	1 litre of dry air	,,	,,	14·42 criths = 1·2932	,,

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